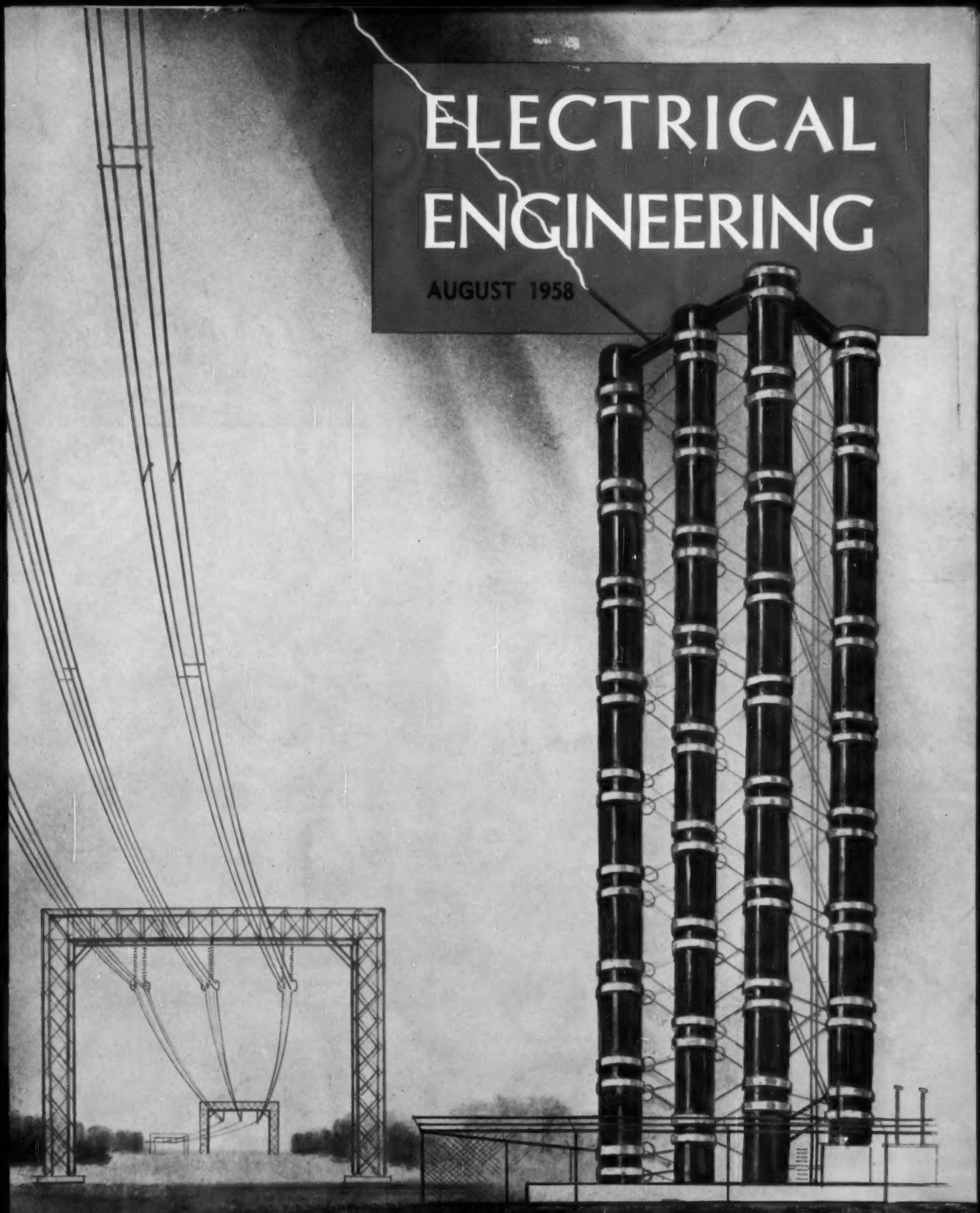
ELECTRICAL ENGINEERING

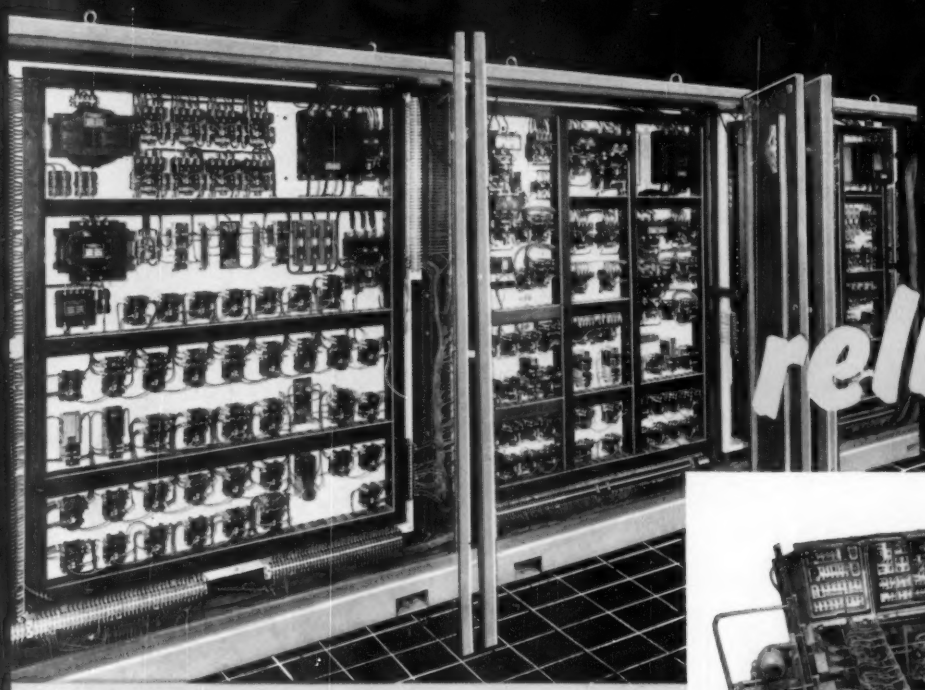
AUGUST 1958



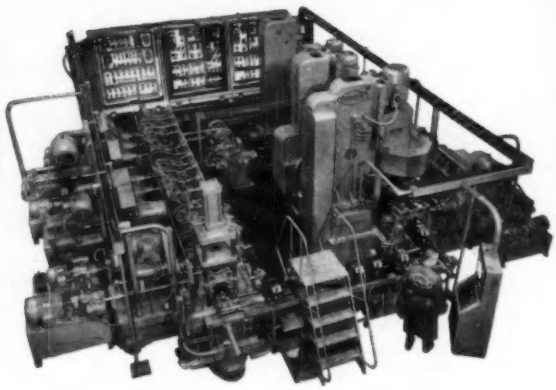
TRANSMISSION RESEARCH AT 460-750 KV

BUNDLE CONDUCTORS SHORT-CIRCUIT TESTS

DEMANDS OF AN EXPLOSIVE ERA



preferred . . . because it is reliable!



This Baker Automatic Transfer Machine is equipped with a special Allen-Bradley control panel, assembled from standard components listed in the latest A-B Handy Catalog.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Twenty-six machining operations are performed automatically on this huge transfer machine. To keep this machine operating continuously—to avoid costly production shutdowns—Baker Brothers, Inc., selected Allen-Bradley quality motor control—the simple control that is good for millions of trouble free operations.

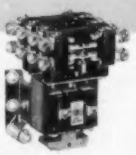
The recognized reliability of Allen-Bradley motor starters and relays is the result of their simple design. Having only *one* moving part, wear and consequent trouble are reduced to the minimum. The double break, silver alloy contacts . . . standard throughout the Allen-Bradley line . . . never need attention. They are always in perfect operating condition.

Simplicity of design and silver alloy contacts are features of all Allen-Bradley control auxiliaries—they are similarly trouble free. Therefore, standardize on the Allen-Bradley line of *quality* motor starters, relays, push buttons, limit switches, and other accessories. You cannot possibly make a mistake!

Allen-Bradley Co., 1301 S. First St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

BULLETIN 802T
Oiltight Limit Switch

Has completely sealed operating head and switch body. This adjustable roller lever type saves installation time.



BULLETIN 700
Solenoid Relay

Universal type relay has contacts that can be connected for either "normally open" or "normally closed" operation.

BULLETIN 709
Solenoid Starter
(Size 1)

Popular across-the-line starter with accurate and reliable overload relays. 8 Sizes to 300 hp, 220 v; 600 hp, 440-550 v.

A-B
QUALITY

ELECTRICAL ENGINEERING

AUGUST 1958
Vol. 77, No. 8

Published monthly by American Institute of Electrical Engineers

THE COVER: Impulse generator, to make surges of artificial lightning will be erected near General Electric Company's extra-high-voltage power line near Pittsfield, Mass., is shown in artist's rendering. Lightning impulses will be used to test performance of the line, which will attain super voltages higher than any ever used by man for the transmission of electric power. Story appears on page 669.

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Project EHV — *P. A. Abetti* — 669
A large-scale investigation being conducted on extra-high-voltage transmission involves the construction of a complete prototype system

Demands of an Explosive Era — *C. H. Linder* — 674
Today's compelling need, a responsibility of all of us, is that of absorbing the impact of science and technology for the common good

Today's Challenge to Engineering Initiative — *J. K. Hodnette* — 682
Engineers must produce more efficient machines and production methods to help restore the balance between wages and prices

ECPD Acreditation of Engineering Curricula — *C. F. Chambers, G. F. Branigan* — 686
The operation and history of the accreditation program of the Engineers Council for Professional Development are described

Electron Tube Evaluation for Guided Missile Applications — *H. G. Chandler* — 690
Evaluating tubes for guided missile applications through excitation of a tube resonance for prolonged periods

Delete John Wood — *R. A. Chipman* — 694
Some dead "Wood" is removed from the early history of electrical conduction placed there by a spare-time historian

Instrumentation for a Boiling Water Reactor — *Lester Kornblith, Jr.* — 696
A description is given of the instrumentation for the Vallecitos Boiling Water Reactor in California

Determination of Optimum Transmission Voltage — *R. D. Camburn, R. L. Stafford* — 700
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Fundamentals of Infrared — *M. S. Juzycz* — 704
Basic information on infrared which has emerged in the last decade from the research laboratory into the domain of applied science

Digital Computers for Distribution Systems — *D. N. Reps* — 708
The general nature of the "computing revolution" and, specifically, the future for computers in distribution engineering

The Philosophy of Engineering Reliability—Part II — *M. L. Miller* — 714
Second half of a two-part article turns attention toward using the definition of reliability for devising methods of measurement

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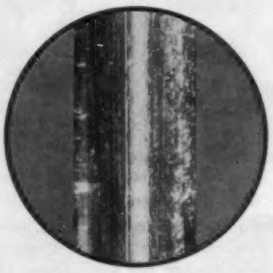
There is a Clear Relationship Between the Cleanliness of a Paper Cable's Components and its Ultimate Reliability . . .

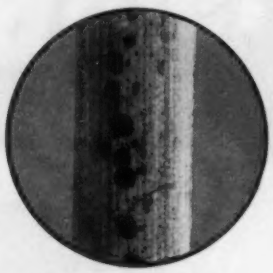
Immaculate cleanliness is an absolute "must" in every aspect of paper cable manufacturing. Take, for example, Okonite's special attention to conductor strands. An extra operation cleans them prior to their being made into a conductor. Each wire is pre-cleaned—thoroughly "washed" and "scrubbed" before it enters the stranding machine. This process removes dust and metal particles, but most important of all it also removes the residual soap and tallow lubricants common to all wire drawing operations. Such impurities, when combined with a cable's impregnating oil, can cause deterioration of the paper insulation and subsequent failure of the cable.

R. C. Waldron
Manager of Engineering

Okonite's painstaking cleanliness measures, also, help maintain the original low power factor of Okonite Paper Cables. For this reason, even the metal binder tapes used in Okonite cables are thoroughly pre-cleaned—just the same as the conductor strands. In fact, every practical effort is exerted to make the components of Okonite Paper Cables as clean as possible.



cleaned strand



uncleaned strand

. . . might mean the difference between success or failure

Properly-shaped Sector Conductors Contribute to the Life Expectancy of Paper Cables

Since voids in a paper cable's insulation can cause cable failure, it is essential to eliminate every possible source of their occurrence. One source of "void" trouble is the shape of ordinary sector conductors. Because their flat surfaces make it difficult to wrap paper tapes tightly around them, the tapes do not "hug" the entire surface of the conductor. They tend to merely contact the flat areas "loosely" or not at all. Therefore, not only can voids develop between the flat surfaces and the first layer of insulation, but—due to the "slack"—they also tend to appear in the wall of insulation itself.

Realizing this flat surface "danger zone" existed in ordinary sector shape conductors, Okonite engineers designed conductor shaping dies that would form a continuous, convex surface about the entire circumference of sector conductors. As the accompanying diagram shows, the new Okonite sector design insured that each layer of paper tape would fit snugly around the conductor. Therefore, "danger zone" voids were effectively eliminated.

1. Carefully cleaning the cable's components, and
2. the development of an improved sector conductor . . .

. . . two concrete illustrations of the meticulous care that Okonite exerts over its paper cable manufacturing operations. This is all evidence to the fact that Okonite paper cables contain *added values*, values that are not written into specifications.

Today, every good engineer I know is seeking ways to get the maximum value out of the money he invests for his company or client. The *added values* in Okonite paper cables provide an opportunity to get extra life and dependability out of electrical cable systems. As one engineer to another, I urge you to become better acquainted with the long range economy of Okonite paper cables.

If you have not received your copy of the new Okonite paper cable catalog, or if I can be of help to you with a current problem, please get in touch with me at The Okonite Company, Passaic, N. J.

6057

Ordinary sector shape

Flat surfaces . . . "slack" in paper tapes . . . voids . . . cable failure

Okonite sector shape

Continuous convex surfaces . . . snug fitting paper tapes . . . solid wall of insulation . . . long life, reliable service

where there's electrical power
***. . . there's* OKONITE CABLE**

For more information circle 1 on reader service card.

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"X-RAY" VIEW of the SRT, showing the volt-sensitive regulating mechanism at the top of the core-coil assembly and the under-load tap changer at the lower part. SRT's will be available in the following ratings:

2400 volts, 10 through 25 kva
4160 volts, 10 through 37½ kva
4800 volts, 10 through 50 kva
7200 and 7620 volts, 10 through 75 kva
12,000 and 14,400 volts, 10 through 100 kva

L-M Announces the

SRT

THE WORLD'S FIRST

Self-Regulating distribution Transformer

A Revolutionary New Engineering Development That Offers Utility Companies Better Revenue, Better Service To Their Customers

By **A. R. WAEHNER**
Director, Transformer Sales, Line Material Industries

The new L-M Self-Regulating Transformer consists of a Round-Wound® distribution transformer with extra taps on the *primary*, and a regulating mechanism that is volt-sensitive on the *secondary*.

The device switches primary taps, *under load*, to change the transformation ratio as needed to maintain a constant normal voltage to the customer, regardless of line or load changes. The SRT provides 10% of regulation in four 2½% steps.

Better Revenue For The Utility

The SRT is a break-through into a whole new world of customer service and profitable operation, because it corrects the voltage *at the point of use*. By maintaining proper voltage, the SRT prevents the drop in billings caused by *undervoltage*, which in the aggregate can represent a considerable loss.

Improves Service To Customers

With correct voltage, lights are brighter; television sets, clothes dryers, air conditioners, and other electrical devices operate more efficiently; ranges heat faster.

The SRT also prevents *over-voltage* from reaching the user. This greatly reduces burnouts of TV tubes, and of incandescent lamps—the latter a very obvious saving to a utility with a lamp-replacement program.

The SRT is another outstanding contribution of The Thomas A. Edison Laboratories of McGraw-Edison Company.

Features Of The SRT

Adapt-a-Tap Range Selector: The SRT provides a full 20% range within which taps for the 10% automatic regulation in four 2½% steps may be selected—all below, straddle, or all above normal. Thus the SRT can be located anywhere on the line—the end, the middle, or near the substation.

Nominal 3½-Volt Band Width: The midpoint is set, for example, at 120 volts. The SRT changes taps whenever the voltage drops to 118¼ or rises to 121¾. Each operation occurs only after a time delay, which prevents undesirable operation and "hunting" on switching surges and momentary variations outside the band width.

Reliability: One 2400-volt tap changer has now operated more than 250,000 times—equivalent to over 40 years' life on a 25 kva transformer.

Economy: Under normal conditions the SRT will prove more economical than other means of voltage correction. Thus it opens unlimited horizons to the distribution-system planning engineer for more effective design.

Available For Tests

The initial production of the SRT will be sold to progressive companies to explore the benefits, in improved revenue and better customer service, that are available from this outstanding new development. Thus each company can learn, for itself, the extent to which the SRT can make a substantial contribution toward keeping revenue up and costs down.

Get The Details

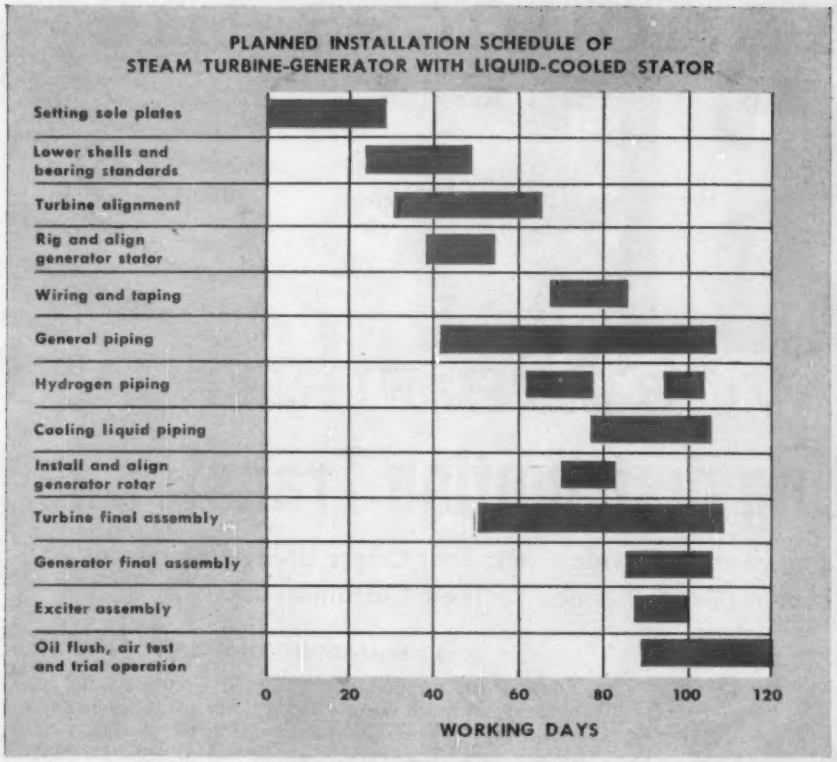
L-M Field Engineers and Apparatus Specialists can furnish detailed information about the SRT. If you would like this information, please get in touch with your L-M Field Engineer, or phone or wire me at Line Material Industries, Milwaukee 1, Wisconsin.

LINE MATERIAL Industries
McGRAW-EDISON COMPANY
Distribution Transformers

McGRAW EDISON

350

For more information circle 2 on reader service card.

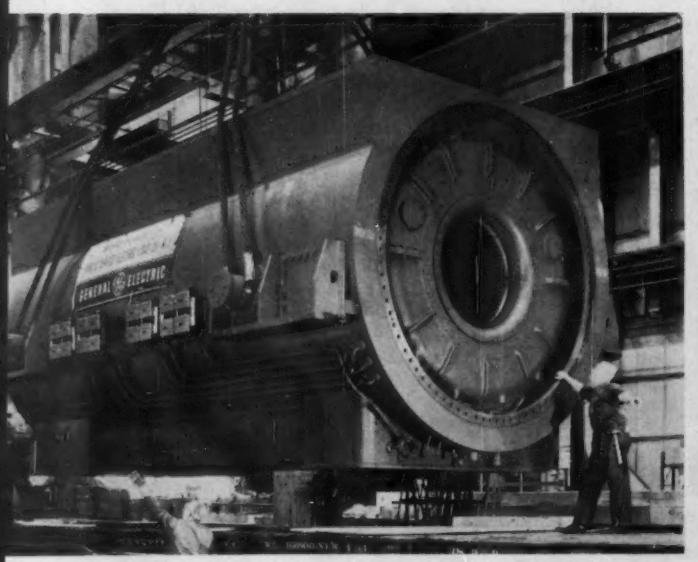


INSTALLATION TIME of liquid-cooled generators approximates time cycles established for conventionally-cooled units. Because of the simplicity of these units, no special assembly techniques are required.

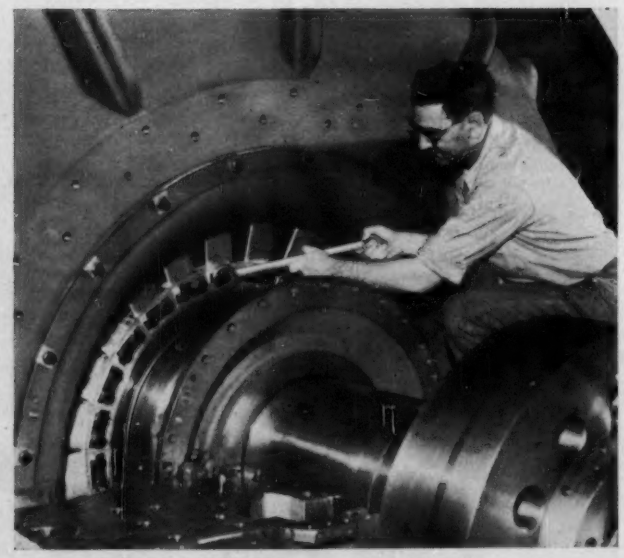
INSERTION OF ROTOR into liquid-cooled stator is accomplished with the same ease as for conventionally-cooled units.

WITH HIGHER RATINGS NOW POSSIBLE FOR GENERAL ELECTRIC GENERATORS...

Simplicity of direct cooling components

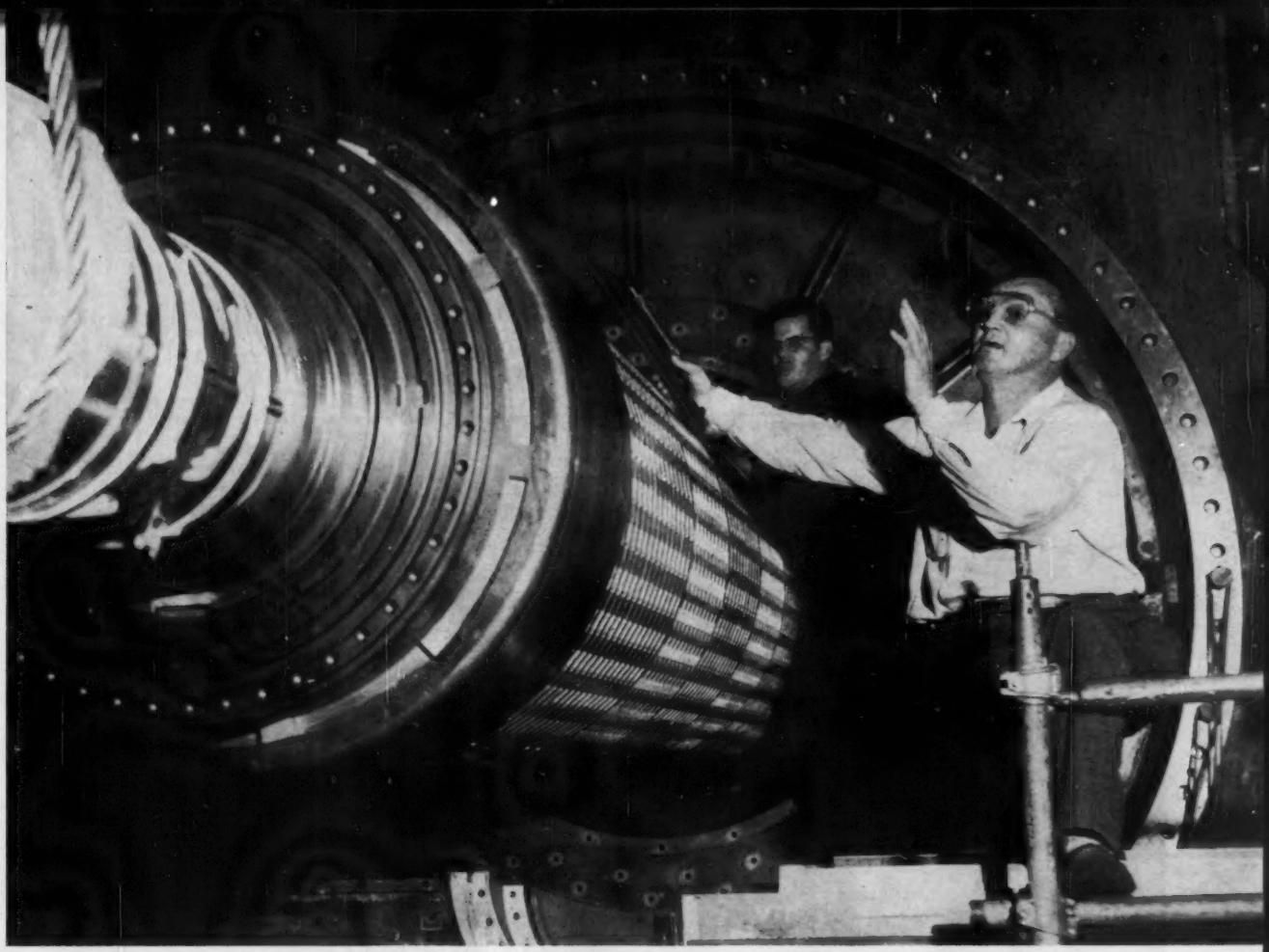


A SINGLE CRANE LIFT can handle this typical 291,000 kva liquid-cooled generator stator. The smaller size and lighter weight of these units are important shipping and installation considerations.



SINGLE-STAGE, AXIAL-FLOW FAN, inner end shield and fan nozzle ring are quite accessible. Complicated end shields and multi-stage fans are not needed on liquid-cooled generators.

For more information circle 3 on reader service card.



speeds assembly, increases availability

SINGLE-STAGE, LOW-PRESSURE FAN ASSEMBLY IMPROVES ROTOR ACCESSIBILITY

The successful application of liquid cooling to generator stators has made possible tremendous increases in unit ratings—yet, with all their advantages, these generators have retained the basic design simplicity found in conventionally-cooled units.

Rotor assembly, for example, is considerably simplified for these higher-rated units. Since liquid cooling eliminates requirements for multi-stage fans and complicated end-shield assemblies, labor assembly costs and inspection downtime are reduced.

Equally important, the increased output possible with liquid cooling means that, on a per kw basis, components are relatively smaller and weigh less. This consideration reflects savings in shipping and handling costs and supporting foundation mass.

Ease of assembly and disassembly is just one of the many important advantages of General Electric liquid-cooled generators. Other outstanding features are:

Increased Generator Output—*Hollow-strand stator bar construction can remove up to 16 times more heat than conventional cooling arrangements, permitting higher generator ratings.*

Improved Performance—*Liquid cooling permits automatic regulation of stator winding temperature independent of load.*

Dependable Operation—*Many unique features are incorporated into the design of the closed coolant system to provide a permanently tight liquid circuit.*

Design Simplicity—*Dielectric system maintains the simplicity and dependability of conventionally-cooled machines.*

For more information on liquid cooling, contact your nearest Apparatus Sales Office or write to Section 254-73 for bulletin GER-1231, Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, New York.

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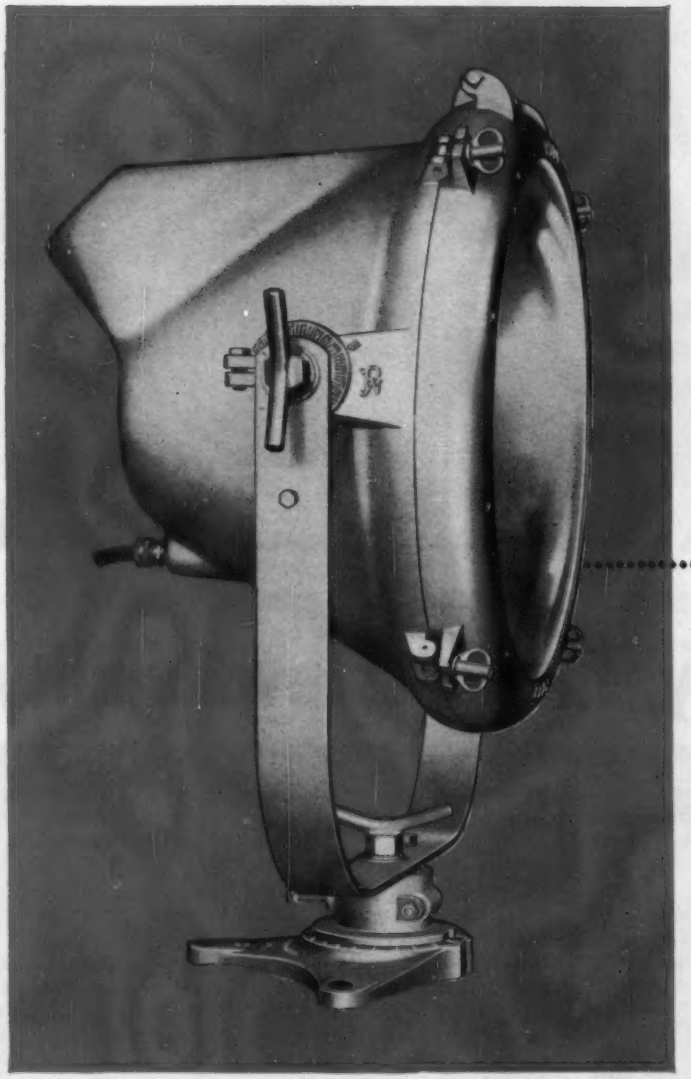

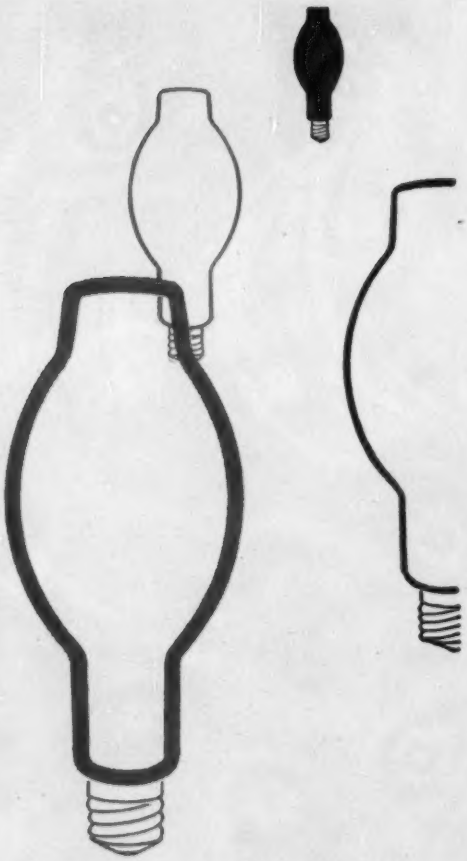

.....rain-tight
dirt-tight
corrosion-proof

The high lumen output and long life of mercury vapor lamps have now been combined with the many advantages of rugged, enclosed, cast aluminum floodlight housings. Since they are corrosion-proof and sealed to protect the interiors from dirt and moisture, the original high efficiency of lens and reflector is retained indefinitely. The result—prolonged economy with exceptionally low maintenance and replacement expense.

Floodlights are available in a wide range of sizes for mercury vapor lamps from 100 to 1000 watts. Choice of specular or diffusing reflectors and five types of lenses provide a selection of beam patterns varied enough to meet the most exacting floodlighting specifications. Enclosures have universal body adjustments and are available with many types of mounting bases.

Send for Bulletin No. 640 containing latest information on operating and color characteristics and operating economies of available mercury vapor lamps; how to select ballasts; short cut method for estimating floodlighting installations with selection tables and sample layout diagrams.

Mercury Vapor Industrial Lighting Fixtures
Explosion-proof, dust-tight, and vapor-tight industrial lighting fixtures are available for mercury vapor lamps as well as incandescent lamps.

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CONDUIT FITTINGS • MOTOR CONTROLS • SWITCHES • PLUGS AND RECEPTACLES

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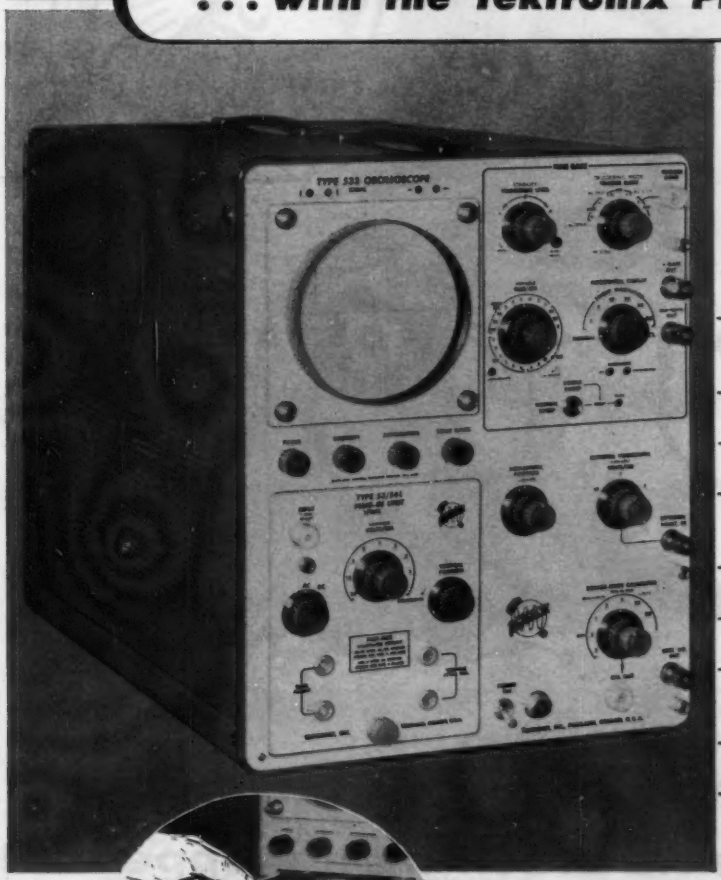
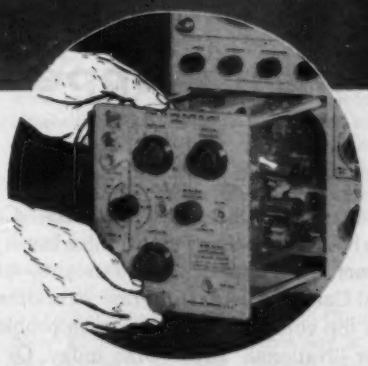
. . . with the Tektronix Plug-In Feature





TYPE 533
Special Features

- **2, 5, 10, 20, 50, and 100 times sweep magnification.**
- **Easy triggering for most applications—Complete triggering facilities for all applications.**
- **High Reliability—13 new frame-grid twin triodes replace older types.**
- **Lockout-reset circuitry for single-sweep recording.**
- **10-KV Accelerating potential provides bright trace (250-cm/μsec writing rate)**
- **Single-Knob selection of 24 direct-reading calibrated sweep rates.**
- **Wide-band main vertical amplifier—0.022-μsec risetime.**
- **Nine Plug-In Preamplifiers available for quick conversion to specialized applications.**
- **Blanking of switching transients in dual-trace operation.**
- **Warning lights for uncalibrated sweep-rate and magnifier settings.**

PRICE, without plug-in units, **$1050**
Prices f.o.b. Factory

ADD SWEEP LOCKOUT *to your Tektronix Type 531 and 541 Oscilloscopes—order Modification Kit*

K531 Sweep Lockout, Tek. 040-118 . . . . . $25
for Type 532
K532 Sweep Lockout, Tek. 040-147 . . . . . $25

Complete specifications for the Tektronix Type 533 are available. Your Tektronix Field Engineer or Representative can usually arrange demonstrations at your convenience. You can call on them for assistance without obligating yourself in any way. Please take advantage of this Tektronix Service whenever you have an instrument problem.

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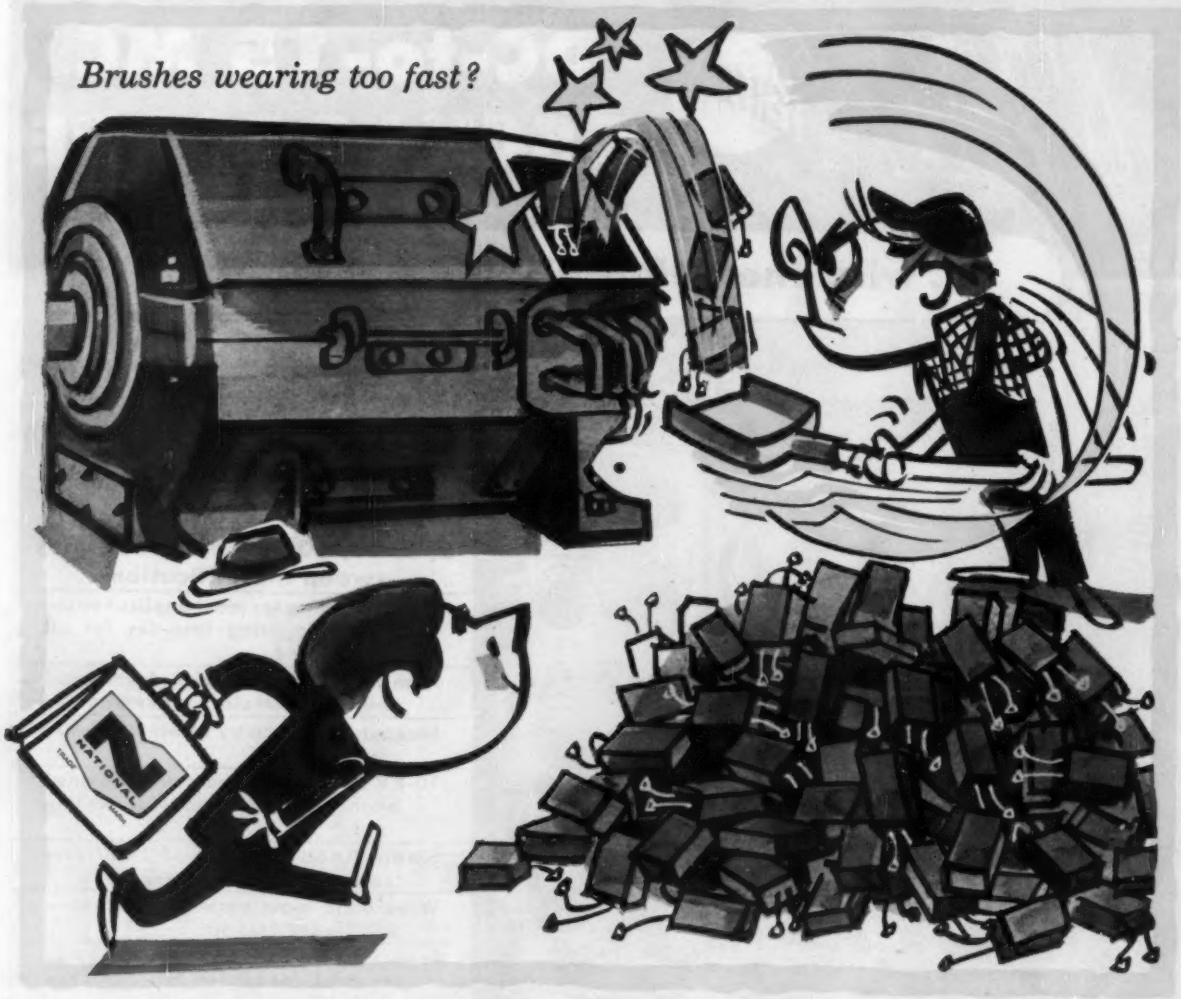

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The mill motors in this eastern steel mill were extra hard on brushes says "National" Carbon Brush Man, A. S. Callaway.

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"Cal" Callaway and his fellow "National" Carbon Brush Men have been helping plants solve brush problems for years. Their experience and training—backed by National Carbon's *long term brush development*—make them top consultants on any brush problem.

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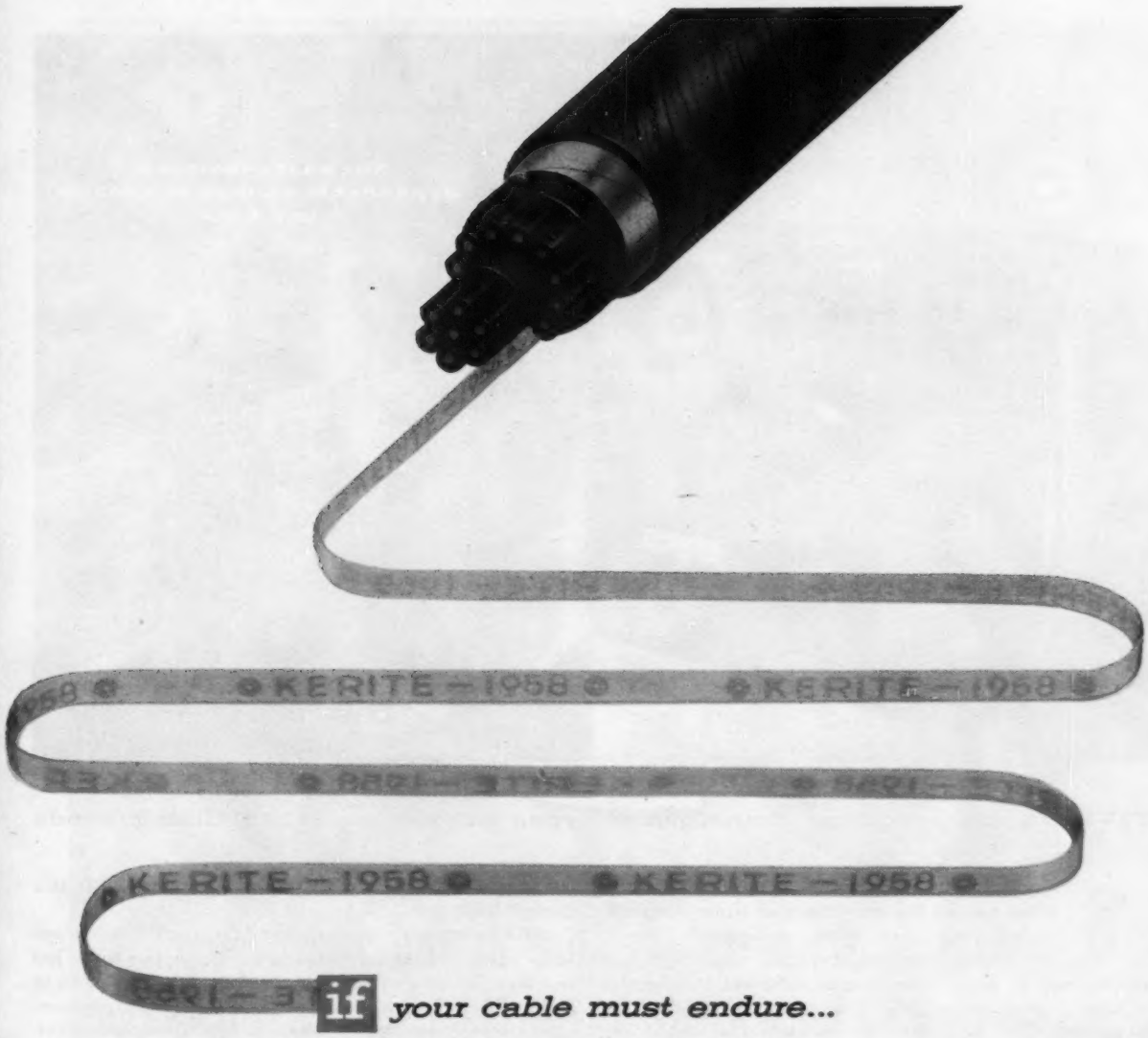

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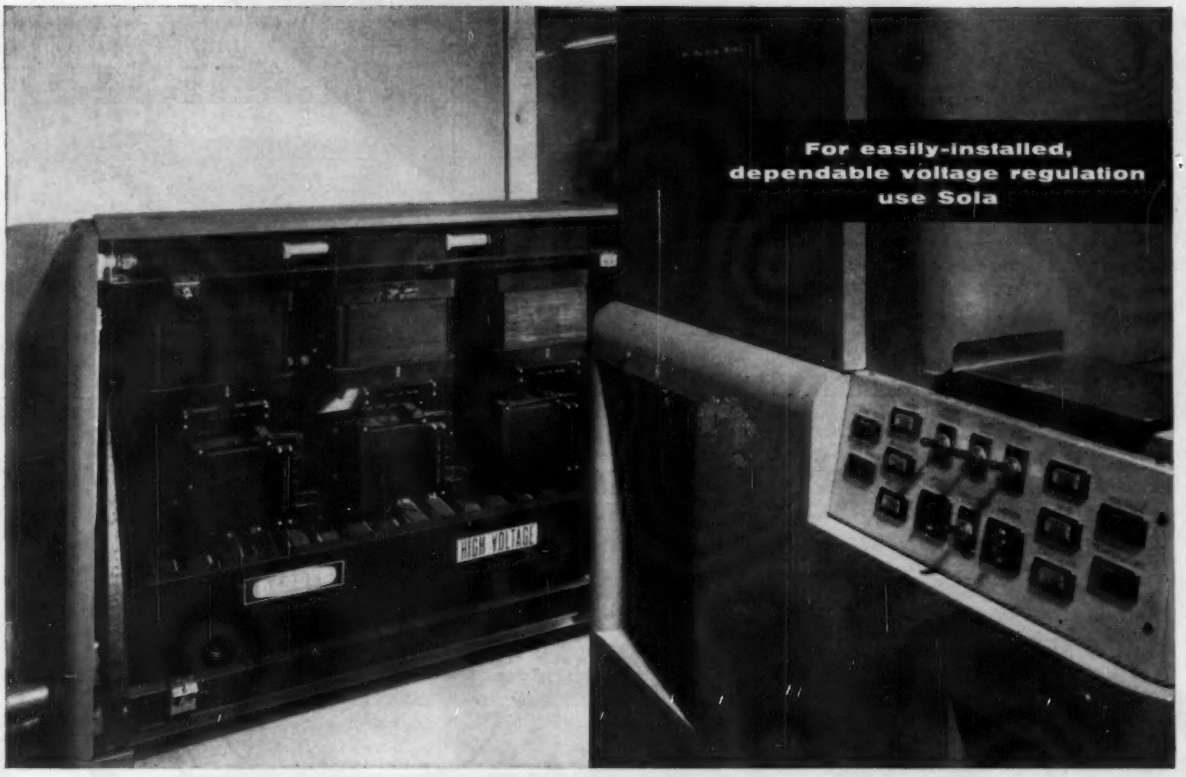

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Sola harmonic-free regulators deliver ±1% regulation with ±15% line voltage variation. The output wave has less than 3% total rms harmonics. Available from stock in seven sizes ranging from 60 va to 3kva; custom designs manufactured to your specifications in production quantities.

2 **Standard*:** Constant Voltage Transformers for electrical and electronic equipment . . . regulation ±1% . . . response within 1.5 cycles . . . no tubes, moving parts or manual adjustments . . . static-magnetic regulation . . . limits current on load faults.

3 **Plate-Filament*:** Regulation is ±3% with line input between 100–130v . . . plate and filament windings are combined on a single, compact core for chassis mounting . . . good isolation of input and output circuits . . . automatic, static-magnetic regulation.

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5 **Adjustable, Harmonic-Free:** Provides output adjustable from 0–130 volts ac, also fixed 115 volts ac . . . regulates within ±1% with less than 3% total rms harmonic content . . . portable for lab or shop bench use, or mounts on 19" relay rack.

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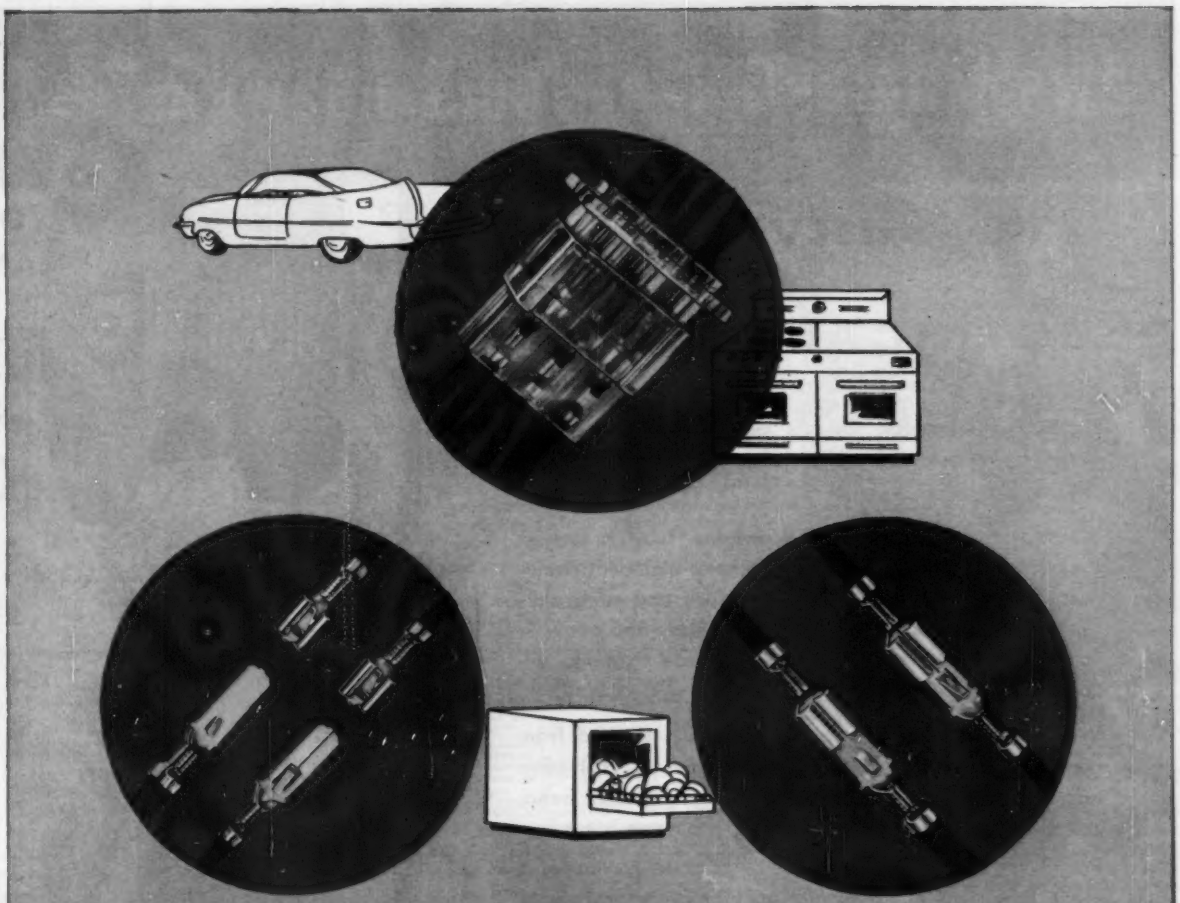

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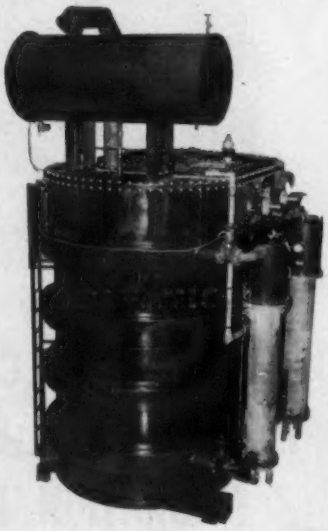
TUBING TO SERVE THE ELECTRICAL INDUSTRY

FROM TRANSMISSION

TO HEAT DISSIPATION



Eliminating many of today's purchasing problems is easy—if you have a supplier versatile enough to supply *all* your needs.

Where tubing is concerned Wolverine Tube is such a supplier. From Wolverine, for example, electrical manufacturers can specify both prime surface and integrally-finned tube in a wide range of types, sizes and alloys—for installations ranging from transmission cable to oil-cooled condenser operations.

When requirements call for tubular parts shaped from copper, copper-base alloys or aluminum tube, Wolverine has both the facilities and know-how to fin, spin, bend, coil, flare, expand and bead tubing—to name but a few of the fabrication techniques available.

Next time you need tubing or tubular-shaped parts specify Wolverine—assure your company of products and services backed by years of experience, constant research and sound engineering. For complete information write for Wolverine's Tubemanship Booklet.

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Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

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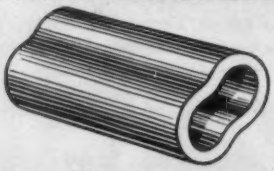
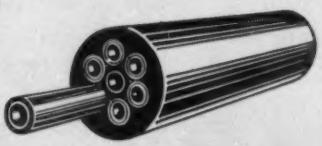
For such operations as transformer oil cooling Wolverine condenser tube is available in two forms—Wolverine Trufin® the integrally-finned tube and prime surface in a wide range of alloys and sizes.



Readily fabricated from Wolverine prime surface copper and aluminum tubing, are electrical connectors such as that illustrated above. Wolverine tubing is available in a wide range of sizes.

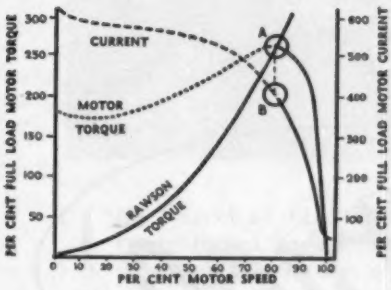


Wolverine tube for such intricate operations as transmission cables is available in copper and aluminum.

For more information circle 10 on reader service card.

Rawson Electrical Design News

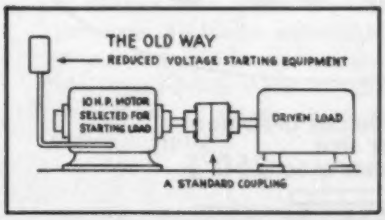
LOWER STARTING EQUIPMENT COSTS MADE POSSIBLE BY NEW RAWSON CLUTCH

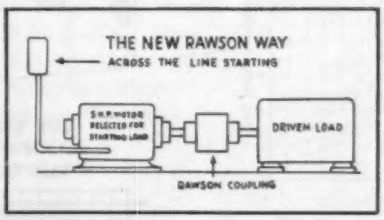


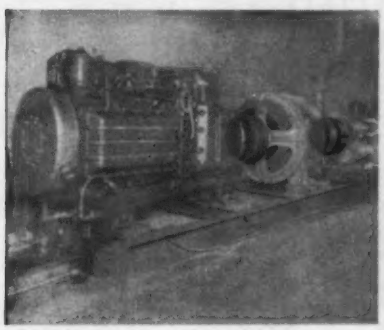
Want a new starting point for cost-cutting? With Rawson Clutches or Clutch Couplings in a start-drive system, you can switch from costly high-torque motors to standard, all-purpose motors for starting high-inertia loads.

The accompanying chart shows how a Rawson permits a standard NEMA B motor to start without load. The clutch does not fully engage until peak torque speed (A) is reached. Motor acceleration time is cut to a fraction of a second, decreasing the peak current period and allowing more efficient motor operation (B).

Thus, the expense of reduced-voltage equipment is eliminated, because Rawsons give cushioned "no load" starts to even the heaviest machinery.







Versatility in Dual Drives

Rawson Clutches and Clutch Couplings are used in the transmission of power from nearly every motive source: A.C. and D.C. motors, diesel and gasoline engines, and turbines.

One use finding more and more applications every day, is in the coupling of standby power units and dual drive setups. Rawsons permit one of two power sources to be used without uncoupling the other. In addition, they provide a simple means of starting or warming up an engine or turbine at a predetermined idle speed without clutch action.

Versatile Rawsons give fluid-smooth starts and transmit maximum power driving in either direction.

Reduced Maintenance

Motors last longer because they operate at low current and proper cooling conditions during the starting cycle, even though Rawson Clutches and Clutch Couplings permit the load to reach full operating speed quickly.

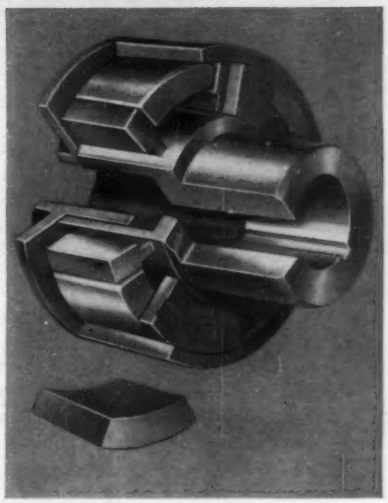
The clutch itself lasts longer too, transmitting maximum power during the life of the unit, while all the time protecting driven machinery or delicate workpieces by eliminating starting shock.

There's no fluid level to check in a Rawson, and no preventive maintenance schedule to worry about, because dust and other foreign matter can't effect its operating efficiency.

Thermal Protective Switch

The Rawson Clutch is a dependable device which protects driving and driven equipment from damage caused by overloads. In remote or unattended installations, where the protective devices built into the electrical starting mechanism will not remove the motor from the line, a Rawson Thermal Protective switch is recommended. Here's how it works:

As the Rawson absorbs energy caused by the overload condition, the Thermal Protective device receives radiant heat which activates the switch, disconnecting the motor circuit. Rawson Type TP switches are used with motors of any voltage operating in 110-volt control circuits. 58RC-5



NEW METALLIC FRICTION SEGMENTS IMPROVE PERFORMANCE—LAST LONGER

Rawson automatic centrifugal clutches and clutch couplings utilize *metallic* friction segments for unparalleled performance and longer life. These segments, or shoes, permit higher operating temperatures and are designed for applications up to 3,000 horsepower, guaranteeing 100% slip-free power at normal operating RPM.

All Rawsons—delayed engagement or free engagement models—provide *instantaneous* overload protection of equipment by disengaging as soon as jamming or overloading occurs. Re-engagement is automatic as soon as jam is cleared.

Standard or Special Models

Rawson Clutches and Clutch Couplings are available in a wide range of types and sizes for a variety of applications. Should you have an unusual power transmission problem, Formsprag sales engineers stand ready to lend a hand in the selection of the proper clutch or clutch coupling. Design service is available to develop a special clutch when necessary.

NEW CATALOG

The new Rawson Catalog contains performance facts, complete specifications, and lists the full line of standard models in a wide range of bore sizes, horsepower and torque capacities suited perfectly to a variety of requirements. Send today.

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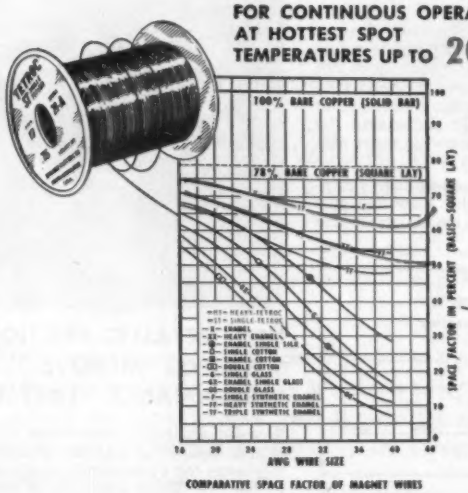
Rawson Clutches and Clutch Couplings Manufactured Exclusively by Rawson Division of O. S. Walker Company.

THESE ARE SPRAGUE'S TWO OUTSTANDING
HIGH-TEMPERATURE MAGNET WIRES

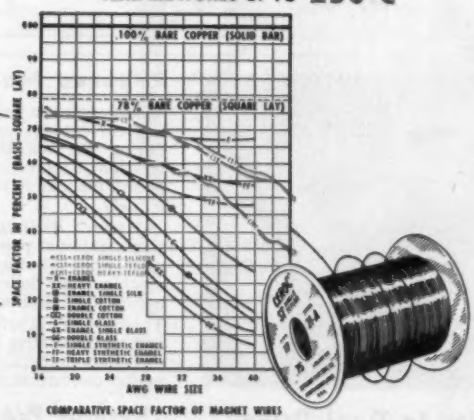
FOR CONTINUOUS OPERATION AT HOTTEST SPOT TEMPERATURES UP TO **200°C**



COMPARATIVE SPACE FACTOR OF MAGNET WIRES

Tetroc®

FOR CONTINUOUS OPERATION AT HOTTEST SPOT TEMPERATURES UP TO **250°C**



COMPARATIVE SPACE FACTOR OF MAGNET WIRES

Ceroc®

SPRAGUE offers you a choice of 2 *truly* high-temperature magnet wires:

TETROC is recommended for continuous operation at hottest spot temperatures up to 200°C (392°F) and up to 250°C (482°F) for short periods of time. Tetroc, a teflon-insulated wire is available in both single and heavy coatings.

CEROC is recommended for continuous operation at hottest spot temperatures up to 250°C (482°F) and up to 300°C (572°F) for short periods of time. Ceroc wire insulation consists of a ceramic base with either single or heavy Teflon overlays—combining the best properties of both materials.

Both Tetroc and Ceroc Magnet Wires provide extremely high space factors.

FOR COMPLETE DATA WRITE FOR ENGINEERING BULLETIN 405 (TETROC WIRES) 400A (CEROC WIRES).

SPRAGUE ELECTRIC COMPANY 321 MARSHALL ST. • NORTH ADAMS, MASS.

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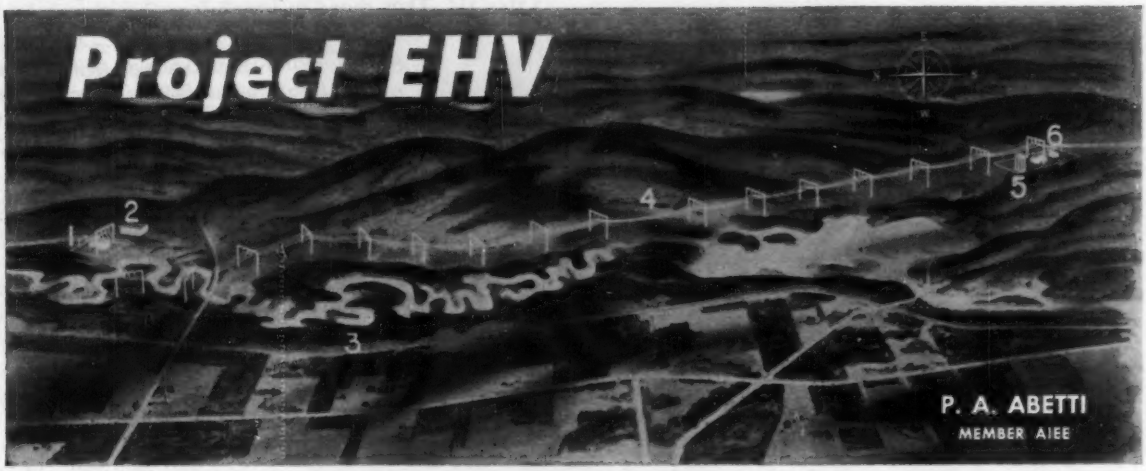
Project EHV



P. A. ABETTI
MEMBER AIEE

▲ Fig. 1. Project EHV line, running 4.5 miles in Berkshire Hills, south of Pittsfield, Mass.

1. Northern terminus
2. Project headquarters
3. Housatonic River
4. Longest span
5. Impulse generator
6. Southern terminus

THE GENERAL ELECTRIC Extra-High-Voltage Project (called "Project EHV" for short) involves the design, construction, and operation of a complete a-c transmission system which will carry power at voltages from 460 to 750 kv. This system will be a prototype of future extra-high-voltage systems. Data obtained from the system will be integrated with analytical studies, model investigations, and laboratory research in all interested components of the participating companies.

PARTICIPATING COMPANIES

1. The General Electric Company, through 15 of its decentralized product departments, will supply the electric equipment and direct the investigation.
2. The Western Massachusetts Electric Company will supply power and later operate the ehv line as an integral part of its system.
3. The Aluminum Company of America will supply the line conductors and conductor accessories.
4. A major steel supplier will furnish the towers.
5. Stone and Webster Engineering Corporation is collaborating with General Electric in the design of the line, and will construct it.

OBJECTIVES

Project EHV has the following objectives:

1. To help re-establish the United States as a world leader in the broad area of ehv power systems.
2. To help prove that ehv systems, in all their interrelated components and aspects, are feasible, more reliable, and more economical for the transmission of large blocks of power over smaller rights of way, than systems presently used.
3. To contribute technical knowledge which will advance the continued expansion of electric power at reduced costs.

P. A. Abetti, manager–systems research, is with the General Electric Company, Pittsfield, Mass.

BRIEF REVIEW OF EHV TRANSMISSION

Two FACTORS should be considered in appraising Project EHV:

1. Present and planned ehv systems (Tables I and II).
2. Experimental a-c lines and available data (Table III).

Operating EHV Systems. As may be seen from Tables I and II, the current situation on ehv transmission is as follows. In this country, eight utilities have now, or are planning to have soon, ehv lines in operation at a nominal voltage of 345 kv with 362 kv maximum. In Canada, one utility has 345-kv lines in operation, with 380 kv maximum. The AEP–OVEC (American Electric Power Service Corporation–Ohio Valley Electric Corporation) system in the East and the Bonneville–British Columbia Electric systems in the Northwest are and will continue to be the nuclei of rapidly expanding interconnected ehv systems. In addition, several private and public utilities in this country and in Canada are actively investigating higher voltage levels than 345 kv, in the 460- to 500-kv range or even higher.

Europeans have progressed to higher voltages than the United States in ehv transmission because of their special requirements of long distances from the points of generating electricity to the point of use. As indicated

Project EHV, a giant investigation on extra-high-voltage transmission, includes design and construction of a complete a-c transmission system to carry power at voltages from 460 to 750 kv, from which it is hoped new knowledge will be gained to benefit the national economy.

Table I. Operating EHV Systems (Above 300 Kv A-C)*

Company or Country	Voltage, Kv Rated	Voltage, Kv Max.	Miles In Operation	Miles Planned Total	Phase Conductors No.	Phase Conductors Diam., Ins.	Year
AEP–OVEC, Commonwealth Edison	345	362	995 D†	1,343 D	1	1.6-1.75	1954
Bonneville Power Administration	345	362	318	—	1	1.6	1956
British Columbia Electric	345	380	315	—	2	1.108	1957
Sweden	380	420	1,655	1,910	2	1.25	1952
USSR	400	440	1,060	3,100	3	1.19	1956
France	380	420	275	775	2	1.04	1957
			—	740	2	1.25	—
Germany	380	420	210 D	1,270 D	4	0.855	1957

* Compiled from references 2 and 3 and additional information, to the best of the author's knowledge
† D = Double circuit

in Table I, four countries have systems now in operation at the 380- to 400-kv level, with 420 to 440 kv maximum. It is planned to expand considerably these four national systems, and several other European countries are building or planning transmission systems at the same voltage level, as may be seen from Table II. Of particular interest is the decision made recently by the Soviet Union to convert its existing 400-kv lines to 500 kv (525 kv maximum) with relatively small modifications. Work is actively progressing for this purpose, and future Soviet lines will also be built for this voltage level. Thus, probably by 1959, the USSR will have the highest operating a-c lines in the world (500 kv) and, probably by 1961, also the highest operating d-c line (2×400 kv).[1] The Swedes are also planning to convert some of their existing 380-kv lines to 500 kv by adding a third conductor to the present bundle of two, but no date has been set. Theoretical investigations of transmission at even higher voltages have been made recently in Sweden (650 kv) and in the USSR (600 to 700 kv). As indicated in Table II, 330-kv lines are being built in Australia and Africa, and 380-kv lines in South America.

The systems described in Tables I and II show a considerable variety in line arrangements and configurations. For instance, at the 380-kv or 400-kv voltage level, the French and the Swedes use two conductors per phase, the Soviets three and the Germans four. It would be interesting to determine whether such differences are justified by variations in the over-all requirements for the design of the individual systems.

Experimental Lines. The transition from a voltage level to a higher one involves a multitude of theoretical and practical problems which have been attacked by one or more of the following means: (1) analytical work, such as economic studies, system stability investigations, etc.; (2) laboratory work, such as impulse tests on apparatus, measurement of radio noise from conductor samples, etc.; (3) experimental transmission lines.

All over the world, a large number of experimental lines have been built specifically to study the problems of ehv power transmission. These lines are listed in Table III. They range in length from less than a hundred feet to 1.4 miles. The 0.6 mile line in Leningrad, USSR, is designed for the highest voltage, 650 kv, but was operated last year only up to 600 kv.[1] Among the best-known experimental lines are the 500-kv Tidd, Ohio, and Leadville, Colo., projects in this country, operated by American Electric Power Service Corporation and the Public Service Company of Colorado, respectively. While considerable knowledge has been gained from all these experimental lines, much of the data vary widely in quality and usefulness. Although some information is excellent, some seems of questionable value. There is need for more adequate proof than can be obtained on purely experimental lines, but which can be obtained on a prototype system operating at ehv.

DESCRIPTION OF PROJECT EHV

THIS BRIEF REVIEW clearly shows that since the end of World War II, there has been a tremendous activity in the ehv field in this country and abroad. Thousands and thousands of miles have been built at voltages higher than 300 kv and electric apparatus of unprecedented voltage and power ratings has been installed. It appears that this activity in the ehv field will be continued at the present rate or will be stepped up in the future. Thus, Project EHV will furnish at an opportune time the technical knowledge required for the transition to higher ehv levels than presently used.

There appear to be important ways in which Project EHV will differ from previous work in the ehv field, in order to attain the objectives previously outlined.

Voltage and Basic Impulse Insulation Level. The operating voltage and basic impulse insulation level (BIL) will be sufficiently high to represent a logical increase over ehv systems now operating or planned (345 to 500 kv) and to permit correlation of data with results obtained on other experimental lines (400 to 600 kv). Therefore, it is planned to investigate voltages between 460 kv, which will probably be the "next step" in this country, and 750 kv, higher than the "second

Table II. Planned New EHV Systems (Above 300 Kv A-C)*

Company or Country	Voltage, Kv Rated	Voltage, Kv Max.	Miles	Phase Conductors No.	Phase Conductors Diam., Ins.
Detroit Edison	345	362	43	2	1.196
Cleveland Electric	345	362	120	2	1.196
Ohio Edison	345	362	100	2	1.108
Pacific Northwest Power	345	362	288	2	1.108
Public Service of Colorado	345	362	?	?	?
British Grid	380	420	1,275 D†	2	1.25
Finland	400	420	575	2	1.293
Switzerland	380	420	50 D	2	1.20
USSR	500	525	2,470	3	1.19
Sweden	500	525	310	3	1.25
Rhodesia	330	345	864	2	1.062
Australia	330	345	800	2	1.06
Argentina	380	420	600	2	1.293

* Compiled from references 2 and 3 and additional information, to the best of the author's knowledge
† D = Double circuit

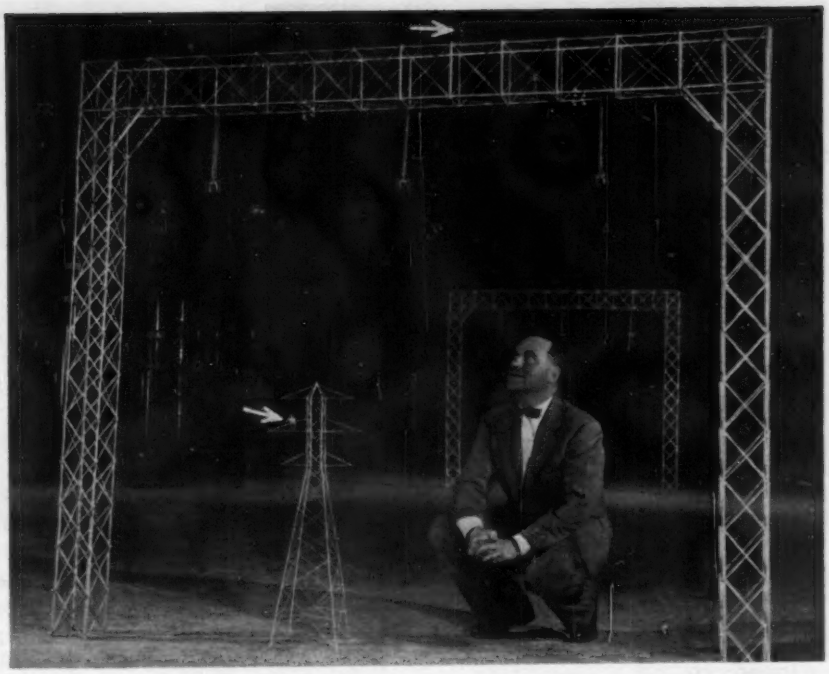


Fig. 2. Author looks at models of 750-kv, 160-foot-high portal tower and of conventional double-circuit 115-kv tower. Note comparative size of men (white arrows) and towers. (Scale of model is 1:25)

next step" in this country. The lower voltage limit of 400 kv will permit correlation with data from the European 380- to 400-kv systems and from the various experimental lines. The upper limit of 750 kv is approximately 50% higher than the next step (460 kv or possibly 500 kv), just as the upper voltage limit of the Tidd Project (500 kv) was 50% higher than the 330-kv level selected for operation of the AEP–OVEC system. The BIL will be approximately 1,925 kv, two steps down, for the nominal voltage of 650 kv at which the system will be operated continuously. The line BIL will be about 2,600 kv.

Line, Conductor, and Towers. The system will be built in the Berkshire Hills (Fig. 1), south of Pittsfield, Mass., near General Electric's Power Transformer Department, which is co-ordinating the project. The length will be 4.3 miles, which will insure representative corona loss and radio noise data. ACSR (aluminum cable, steel reinforced) bundle conductors will be used (Fig. 2), inasmuch as this is the present trend in ehv systems (Tables I and II), with cross sections ranging from 954 to 1,431 MCM ACSR. Conductor configurations to be used include 2, 3, and 4 conductors per bundle. A number of phase configurations and widely different interphase spacings will be investigated. There will be two insulator strings per phase, from 26 to 40 insulators per string, up to 22 feet long (Fig. 3). The towers (Fig. 2) will be of the portal type, among the largest ever built, to insure maximum flexibility in the phase configurations to be investigated. There will be 17 towers in total, 180 feet wide, from 110 to 160 feet high. Spans will vary from 800 to 2,200 feet in length, with the average about 1,500 feet.

Lightning and Impulse Voltages. In order to obtain maximum lightning exposure, 50-foot rods will be installed on top of each tower. Oscillographs and other lightning recording devices also will be installed on each tower. Additional impulse voltages, to simulate lightning and switching surges which can occur in service, will be imposed on the system by a 5-million-volt impulse generator (see cover of this issue).

Data Processing. Inasmuch as one of the primary purposes of Project EHV is to gather information and transform it into meaningful conclusions, the following plan has been conceived. Approximately 200 instruments will be located in five stations along the 4.3-mile line. These instruments will measure essentially four categories of data:

1. Meteorological: temperature, pressure, rate of precipitation, etc.

2. Electromechanical: strains and stresses in the conductors and towers, etc.

Table III. Experimental A-C Lines, Built for Study of EHV Transmission

No.	Location	Number 1φ	Number 3φ	Kv Maximum (3-Phase Equivalent)	Year	Notes*
1	Chevilly, France	1	1	500	1946	Major
	Alpe d'Huez, France	1	–	230	1946	High Alt.
	Puy du Dome, France	3	–	.	1947	Sleet
	Toulouse, France	–	1	230	1957	Power
2	Berlin, Germany	1	–	425	1941	Short
	Southern Germany	3	–	.	1941	Sleet
	Rheinau, Germany	–	1	500	1951	Major
	Schwarzwald, Germany	–	1	.	1952	Sleet
3	Leatherhead, England	–	1	500	1948	Major
4	Baden, Switzerland	1	–	500	1947	Short
5	Tidd, Ohio, U.S.A.	–	3			Major
6	Leadville, Colo., U.S.A.	3	–	470	1957	High Alt.
7	Tanashi, Japan	–	1	435	1951	Major
	Sumitomo, Japan	1	–	435	1951	Short
8	Uppsala, Sweden	1	–	500	1946	Major
	Gotheborg, Sweden	3	–	600	1957	Short
9	Leningrad, USSR	3	–	650	1954	Major
10	AEP System, U.S.A.	–	3	362	1956	Power
11	Bonneville System, U.S.A.	–	1	362	1956	Power
12	Ontario Hydro System, Canada	–	1	270	1957	Power

*NOTES:
Major: Experimental line for comprehensive tests of corona, several hundred to a thousand feet long
Short: Short line, less than a hundred feet long
Sleet: Line to study sleet and icing phenomena and mechanical performance
Power: Line carrying power as part of an operating system
High Alt.: Line built to study effect of higher altitudes (above 5,000 feet)

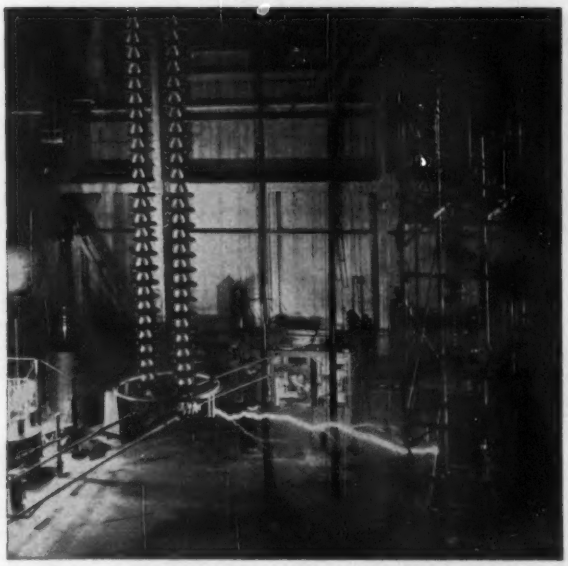


Fig. 3. Insulator string, 22 feet long, for extra-high-voltage line is tested with flashover to simulated tower.

3. Electrical: voltage, current, corona loss, radio interference, etc.

4. Transient Electrical: lightning, switching surges, fault currents, etc.

A master clock in the control center at the northern substation will control all instruments in the first three categories. Every 15 minutes a signal will be transmitted from the clock to all instruments, which will be read simultaneously. The readings in the form of d-c voltages will be changed to digital form by an analog-to-digital converter in each station and transmitted by cable to the control center. Here these numerical data will be printed out (for inspection by the engineer in charge) and recorded on magnetic tape, in IBM *705* computer code. In case of bad weather (rain, snow, strong winds, etc.) at any location along the line, the entire system will go automatically from the 15-minute to a 1-minute cycle but the data will be recorded on magnetic tape only. Every week, the tape will be processed by the *705* computer. The data will be first sealed, then checked for validity, then evaluated according to the most advanced statistical techniques, and correlated by multiple regression analysis. It is estimated that about 10 million items of data will be gathered each year.

System Operation. Project EHV will be more than just a short experimental line carrying only charging current and with limited terminal equipment at only one end. Rather, it will be a complete ehv power system, operating continuously under conditions simulating normal operation as closely as possible. For example, the conductor temperature rise over ambient will be the same as in an actual system carrying loads as high as 2 million kva. This has not been done extensively in previous experimental lines, and will be obtained by circulating currents in the bundle conductors.

The following plan of operation has been established:

1. Early in 1960, the line will be first energized for open-ended operation, to investigate the 460- to 500-kv voltage level (Fig. 4). Number of conductors, spacings, and configurations will be varied to investigate thoroughly this "next step" in ehv transmission.

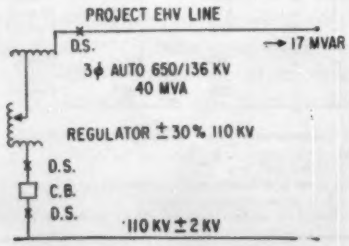
2. Early in 1961, the conductor spacings, insulator strings, and some equipment will be changed to permit investigation of the 650- to 750-kv range.

3. Late in 1961, the apparatus will be installed at the open end of the line to complete the loop with the existing 110-kv line of the Western Massachusetts Electric Company. Project EHV will then operate in parallel with this line, at 650 kv nominal voltage level, carrying loads up to 40 mva (Fig. 5).

4. In 1962, the breaker on the 110-kv line (Fig. 5) will be opened and the 650-kv system will replace the 110-kv line and become an integral part of the Western Massachusetts system. The ehv system will then be fully operated by the utility to obtain further data and actual system operating experience.

5. In 1963, the entire Project EHV will be re-evaluated, in the light of the results obtained and of what researchers elsewhere in the United States and abroad have learned. At that time, it may be decided (a) to continue operation at the same voltage levels to gain additional experience and data, (b) to raise the voltage to a million volts a-c, by rebuilding the towers and terminal equipment (the 300-foot right of way would be adequate for this voltage), or (c) rebuild the entire system for d-c transmission at voltages of the order of 2×500 kv.

Technical Work. As previously indicated, analytical studies and laboratory investigations have been used in the past, in addition to experimental ehv lines, to solve the problems of ehv power transmission. These three means are not mutually exclusive alternatives, but rather they complement each other and are equally necessary to obtain a proved solution. Therefore, Project EHV will be expanded by analytical studies, by



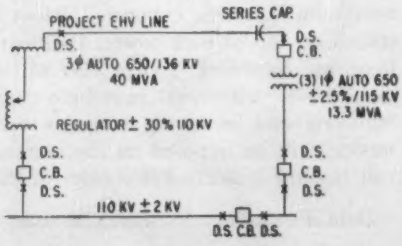
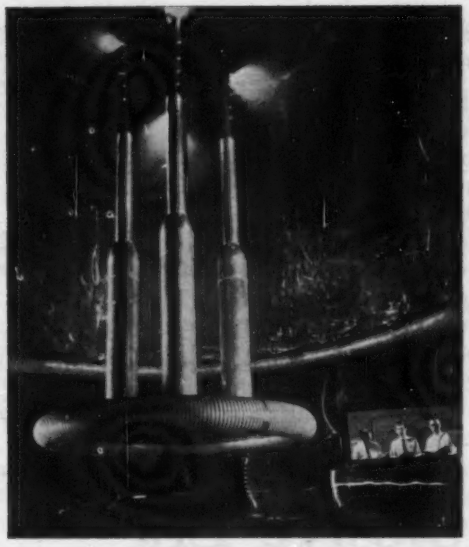


Fig. 4 (left). In 1960, Project EHV line will be first energized for open-ended operation. Fig. 5 (right). In 1961-62, Project EHV loop will be closed to permit power flow.

Courtesy Western Massachusetts Electric Company



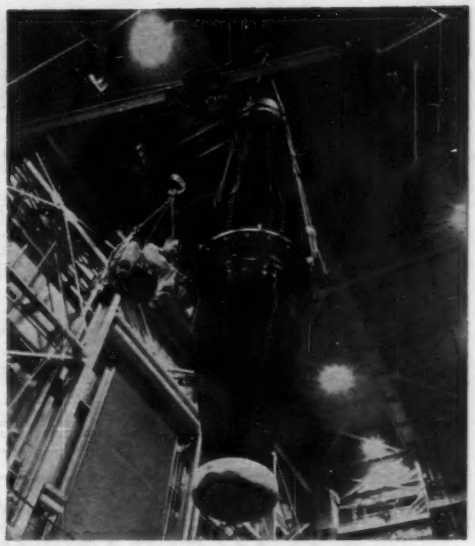


Fig. 6 (left). Glowing electric discharges are measured in GE's High-Voltage Laboratory for corona and radio-noise studies of bundle conductors. Fig. 7 (right). Bushing for 650-kv transformer being checked by technician.

analog models of the various aspects of the system and its components, and by laboratory research. It should be possible not only to determine and explain the performance of this ehv system, but also to predict the performance of future ehv systems that differ from this one. This, in turn, will lead to optimum system design practices.

Therefore, as part of Project EHV, technical work will be done by many components of the participating companies in the areas indicated in the Appendix. In fact, work has been in progress in most of these areas for more than a year, to obtain design data for the 650-kv system. Typical examples of this work are the determination of radio-influence voltage of bundle conductors to be used on the line (Fig. 6), the determination of the impulse characteristics of long insulator strings and of ground clearances (Fig. 3), and the testing of ehv apparatus components, such as a 650-kv, 2,050-kv BIL bushing (Fig. 7).

CONCLUSION

IT IS CLEAR that the scope of the technical work planned for Project EHV is very extensive and involves directly system design and operation.

Because of the emphasis on the system aspect, an advisory council representing the utilities of this country will help determine the scope of research and the parameters of Project EHV. The new knowledge that will result will be of direct interest and benefit to the electric utilities of this country, to the manufacturers of electrical apparatus, conductors, and towers, and to the national economy as a whole, because of the vital importance of electric power to this country's future.

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2. Report of CIGRE Study Committee No. 9, A-C Transmission at High Voltage. P. Sporn. *Report no. 419*, CIGRE, Paris, France, 1958.

3. Characteristics and Cost of Lines at Voltages Higher Than 225 Kv, P. Sporn, F. Cahen, M. Magnien. *Report no. 417*, CIGRE, Paris, France, 1958.

Appendix

Areas of Technical Work

A. System Design and Performance
1. Economics of various a-c voltages
2. Economics of d-c vs a-c
3. Relative cost and influence of each component
4. Optimum conductor size and configuration
5. Economics of system reliability
6. Interaction of apparatus and line
7. Standardization

B. Line Design and Performance
1. Electrical and mechanical design of towers, conductors, hardware, and insulators
2. Corona loss
3. Radio and television interference
4. Mechanical performance of bundle conductors: wind contacts, icing, galloping, electromagnetic and electrostatic forces
5. Sleet prevention and sleet melting

C. Apparatus Design and Performance
1. Power transformers and autotransformers
2. Regulating transformers
3. Current transformers
4. Potential transformers
5. Potential devices
6. Circuit breakers
7. Load-break switches
8. Disconnect switches
9. Lightning arresters
10. Series capacitors
11. Shunt capacitors

12. Coupling capacitors
13. Line traps
14. Shunt reactors
15. Standardization

D. Insulation
1. Lightning
2. Switching surges
3. Power current follow
4. Low frequency overvoltages
5. Continuous service stresses
6. Ferro-resonance
7. Arc deionization
8. Recovery voltages
9. Basic insulation levels
10. Insulator contamination and leakage loss
11. Insulation co-ordination

E. Related System Equipment
1. Carrier current
2. Microwave
3. Relaying
4. Telemetering
5. Airplane warning
6. Conductor heating
7. Power frequency meterings
8. Transient disturbance metering
9. Automatic data origination
10. Electronic data processing

Demands of an Explosive Era

C. H. LINDER
FELLOW AIEE

Today's compelling need is that of absorbing the impact of science and technology for the common good. This is a responsibility of all of us, because each advance affects the whole spectrum of our society and its institutions. The essential requirement is an enlightened citizenry, prepared to submerge individual interests in the group interest and to orient to new values when and as necessary.

VERY FEW PEOPLE are aware of a tremendous tribute which was paid to the power industry almost a year ago. You might easily have missed it, for it happened very quietly. There were no speeches or fanfares; no trophies, plaques, or scrolls. The *New York Times* covered the event not in its news columns, but on the editorial page. The *Times* reported statistics from Washington to the effect that, in our gross national product, the effort spent to provide services exceeded, for the first time in our history, the effort devoted to producing goods.

In an economy as large and complex as ours, this is truly a remarkable fact. It speaks volumes for the contribution of electric power to industrial efficiency and a rising standard of living. We have come to our present ability to produce through the multiplication of man's muscle power by machines; the amplification of man's sensory perceptions through measuring and control devices; and, most recently, the extension by computers of part of man's mind—the ability to perform highly complex logical processes. The result has been the elimination of drudgery and danger from untold numbers of productive tasks, together with an enormous gain in our capability to design and deliver more and more complex products to broader and broader mass markets. Those complex products include, of course, hundreds of devices contributing to the comfort, convenience, and enjoyment of man at home, at work, and while traveling.

No one knows better than we do how utterly impossible any of these achievements would be without electric power—inexpensive power, available in abundance. No one knows better what exercise of outstanding leadership has been required of the electric power industry in pacing the country's demands for power. The essence of that leadership has been the perceptiveness and courage to take great business risks on scientific and technological progress. The developments that have brought us where we are today were not handed to us on a silver tray. Most of them could not be completely proved on paper in advance. Foresight, co-operation, and hard-earned dollars had to be contributed by both the operating and manufacturing branches of the industry, in order that visions could become realities. Our society will always be in debt to the power industry for leadership thus exercised and the results delivered.

Society, however, has a way of acknowledging its debts by demanding more of the same, only better; by setting the past gain as a future standard. The projections of growth in our population, of the expansion of our economy, and of our security needs all add up to demands on the power industry which offer no chance of relaxation. Perceptive and courageous leadership will be required of us more than ever, together with a great increase in plain, everyday hard work. The demands of

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society upon us are not the only factor. The sciences and technologies from which we draw our progress are growing and changing with extraordinary speed. To exploit them for the common good is an increasingly complex task.

EXPLODING SCIENCE AND TECHNOLOGY

THE HUMAN RACE started its career with three basic assets: natural sources of energy, natural sources of food and materials, and human ingenuity. With these three assets, we have created all the extraordinary array of goods and services available for the physical well-being of society today. The process, of course, involves scientific discovery, technological innovation, and application to meet the needs and wants of man.

Historically, this process is much younger than the human race. There were precious few contributors to science and technology prior to the 16th Century, and only a handful, such as Da Vinci, Copernicus, and Galileo from then to the middle of the 18th Century. It is after 1750 that the great "milestone" names begin to multiply: Newton, Priestley, Watt, Lavoisier, and so on up to the present. The contributors mount up rapidly in the decades of the 20th Century.

There is an interesting pattern in the historic process of applying science and technology to meet needs and wants of man. In this particular pattern, which might be called the "sequential approach," the discovery of the fundamental principle comes first. It is followed at some uncertain length of time by the work of the inventor who makes the application. This, in turn, is followed by the work of the entrepreneur who produces and markets the end goods or services. Before 1800, the time lag between discovery and use was measured in centuries. By the early 1900's it was measurable in decades, and a fair estimate of the average in 1950 would be 10 to 25 years.

Now our own immediate times are sharply distinguished by concentrated efforts to shrink this time lag still further. On the one hand, we have the great volume

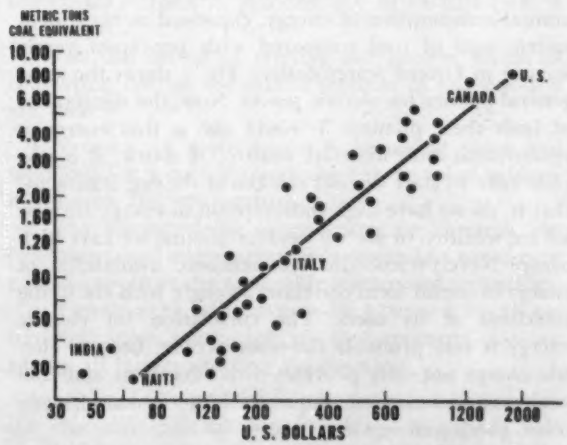

Fig. 1. Per capita energy consumption vs per capita national income, 1952.

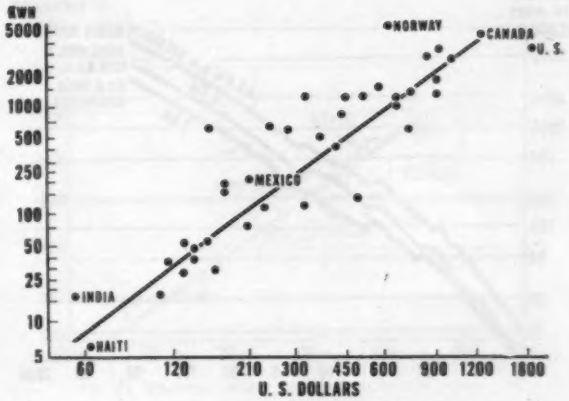

Fig. 2. Per capita electric power production vs per capita national income, 1952.

and variety of human needs and wants; and on the other, we have the knowledge, facilities, and skills of business and industry. We constantly seek to match these capacities with human needs and wants in terms of products or services. (The power industry, of course, is not only a major contributor directly to the consumer in its own right; it is also fundamental to the contribution of all business and industry.) Sometimes we start from the perception of a need or want and sometimes from the availability of particular facilities and skills. But what is notable about our efforts today is that industry more and more is co-ordinating activities in research, engineering, manufacturing, and marketing to secure the economic advantage of timely innovation. Whatever activities may be necessary are carried on, to the greatest extent possible, under an over-all plan and simultaneously. In other words, the discoverer, the inventor, and the entrepreneur work in parallel, instead of strictly in sequence.

It is important to remember that rigidly controlled economies—whether socialistic or monopolistic—have a certain advantage in their efforts to squeeze time out of the process of putting science and technology to use. They do not need to allow for the free play of economic forces under a competitive, democratic system.

However, the fundamental point to grasp is that the process through which society has capitalized on its three basic assets is not a simple arithmetic growth process. It is, in fact, exploding; and we could not stop it, even if we would.

ADJUST TO CHANGE

THE GREAT CHALLENGE to us is absorbing the impact of science and technology for the common good. It is of the utmost urgency for us to realize that this is a responsibility of all of us, because each advance of science and technology has impact throughout the whole spectrum of our society and its institutions. It is there that the absorption and adjustments must take place.

Consider, just briefly, as an example of the problem of absorbing, the effects of science and technology on a

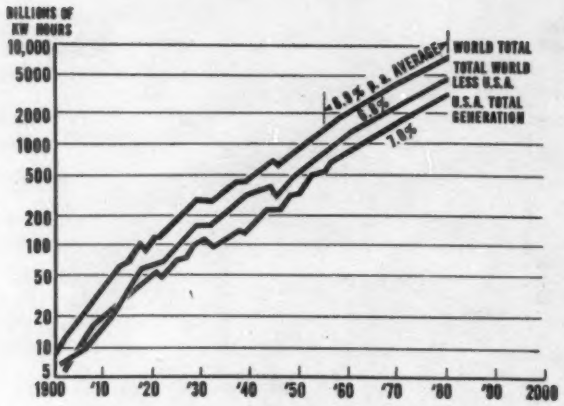

Fig. 3. Production of electric energy.

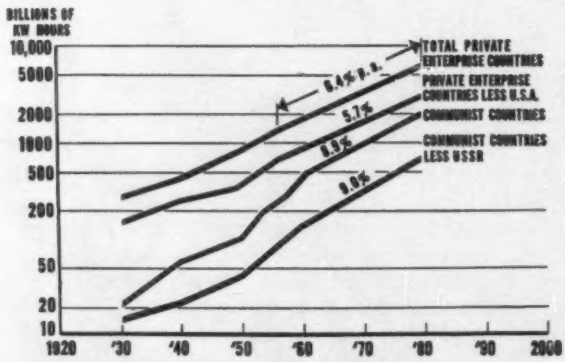

Fig. 4. Production of electric energy in selected portions of the world.

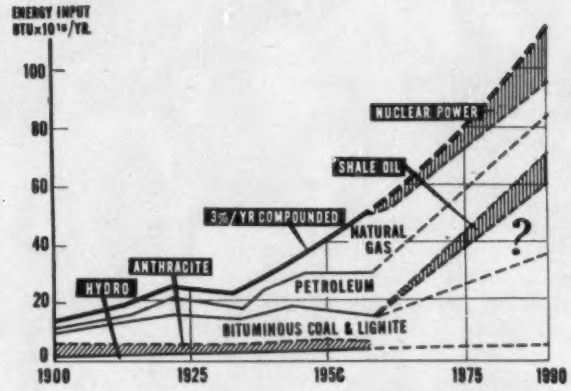

Fig. 5. Input to the energy system of the United States, 1900-1990.

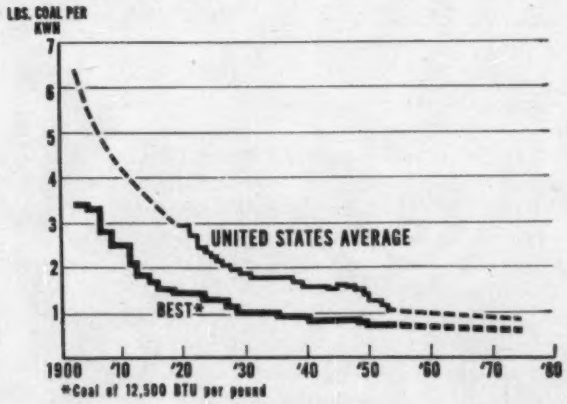

Fig. 6. Station coal rate.

few facets of any national economy. The developments which have led to the conquering of disease and the easing of the struggle for livelihood have brought great expansions of population. Approximately one out of every 20 people who have been born since the beginning of time walk the earth today. Since 1941, the world has gained more than 500 million people, and 25 independent nations. The world population is predicted to grow from some 2½ or 3 billion to 6 or 8 billion by the year 2050. With such greater numbers to feed, house, and make prosperous—and with proved means of doing so at hand—it is no wonder there is competition to control and develop sources of raw materials, energy, and markets. But there is more to it than that. What particular goods and services can the economy most successfully take to market? What raw materials are important to it? How much energy will it need? What kind of work force is required; how many farmers, skilled machinists, engineers, salesmen, accountants, or managers? These are questions for which the economy must find answers, while science and technology constantly change the factors in the solution. As one example, we are all acutely aware of the continuing problem of readjusting our work force to allow for the great increase in the efficiency of agricultural methods. To produce food for 170 million people today, we need less than half the number of farmers we needed only 40 years ago to feed a population of 105 million.

Our own electric power industry is an outstanding example of one which has lived all its life on familiar terms with scientific and technological change. It has done so to date with outstanding success; it must continue to do so in the future.

Fig. 1 shows, on a world-wide basis, the per-capita annual consumption of energy, expressed in equivalent metric tons of coal compared with per-capita yearly income in United States dollars. Fig. 2 shows the same general picture for electric power. Now, the significance of both these pictures, I would say, is that energy is synonymous with material wealth. Of course, it is possible here to start the old chicken-or-the-egg argument: that is, do we have high consumption of energy because we are wealthy, or are we wealthy because we have high usage? Nevertheless, this fact remains: availability of energy in useful form correlates strongly with the living standards of its users. The correlation for electric energy is very probably the more precise, because electric energy not only provides direct comforts and conveniences, but also is essential to the provision of many other goods and services.

Figs. 3 and 4 are predictions on a world-wide basis. Predictions such as these never turn out to be correct in

every detail; moreover, there is often a wide variation of opinion about how they should be made. Nevertheless, they may be useful and significant indicators.

The United States is, of course, the major producer of electric energy in the world. If, however, we consider rate of growth in electric power production, the United States and other private enterprise countries have a substantially lower rate than the USSR and the communist satellite countries. Naturally, they have some catching up to do, but let us have no doubts that they are doing so.

The historic and the projected development of energy sources in the United States have fundamental significance for our industry. As Fig. 5 indicates, energy to meet our requirements is available; the uncertainty (as indicated by the question-mark area) concerns which sources will be developed to the projected level of demand. The lesson for us here is that development of sources is linked to cost and is largely an evolutionary process. The cost of energy itself will be evolutionary. On the other hand, the products and processes for supplying the nation's energy needs might be expected to experience more revolutionary change, as various forces compete for utilization.

Figs. 6 through 10 illustrate some specialized areas of striking scientific and technological change. In Fig. 6, our success in deriving more and more useful electric energy from our natural energy materials is shown. Note, however, how marginal our recent gains have become.

Fig. 7 shows progress through higher temperatures. The trend line represents an arithmetic rate of increase of about 12 F per year. For pressure (Fig. 8), the growth rate is geometric at 6% per year. In Fig. 9, pressure and temperature are combined. Note how we have, in general, advanced along one path or the other independently.

In Fig. 10, the entropy curves are compared. The three areas indicate the gains realized from different heat cycles at three different sets of pressure and temperature conditions. The lower two curves represent conditions realized in practice; the 10,000-psia cycle is theoretical.

In all this matter of refining our present means of converting energy, the salient features of our position are these:

1. Progress in performance is becoming more and more difficult to win through the conventional avenues of pressure and temperature.

2. Sharply increasing expenditures for research, development, and engineering are required to wrest even a small gain from the applicable science and technology.

3. Future work will have to be governed by an exceedingly nice perception of the optimum balance among all factors affecting the objective.

In the area of transmission, two factors of importance are the transmission system voltage (Fig. 11) and breaker interrupting capacity (Fig. 12). These illustrations highlight three major points:

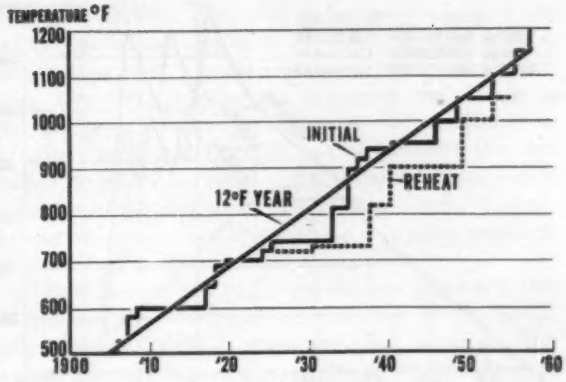

Fig. 7. Maximum steam temperature, United States.

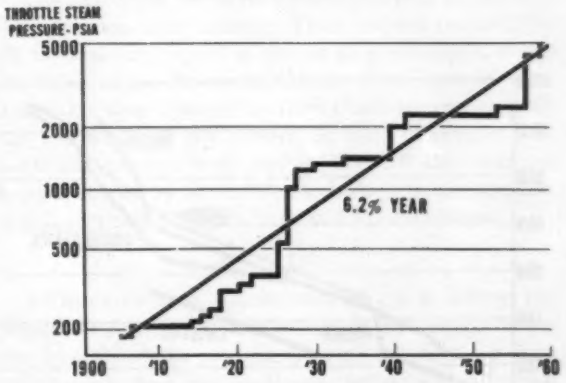

Fig. 8. Maximum steam pressures, United States.

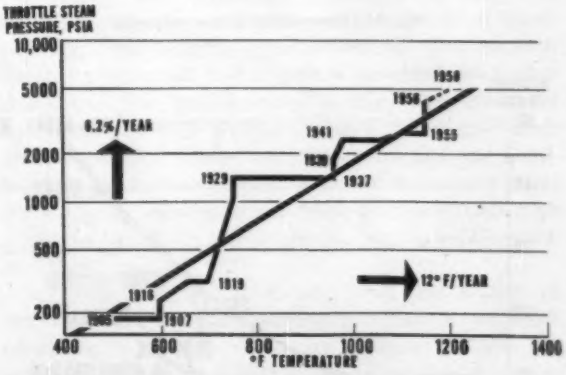

Fig. 9. Maximum pressure vs maximum temperature in U. S. turbine designs.

1. Increasing restrictions in obtaining rights of way are focusing attention on more efficient use of the power corridors.

2. Interconnection of systems is producing both long-line equivalents and high concentrations of power from the viewpoint of protection and switching.

3. We have stood still for some time; it is urgently necessary for the future of power transmission that we seek new knowledge in high-voltage technology.

Now there are two points to be emphasized with

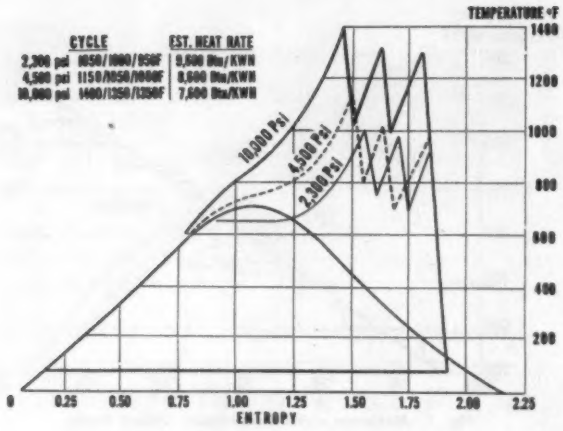

Fig. 10. Comparison of steam cycles.

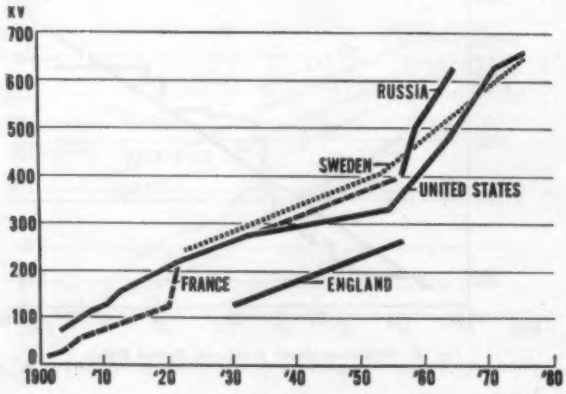

Fig. 11. Transmission system voltages.

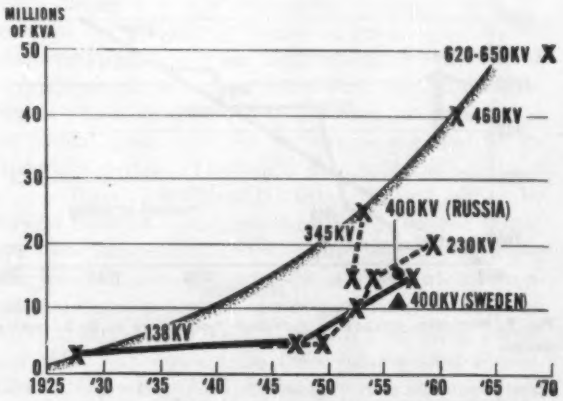

Fig. 12. Breaker interrupting capacity vs year when first used.

regard to our industry and the related sciences and technologies. The first concerns the nature of the tasks ahead of us. We must recognize that the majority of our problems do not involve merely doing better what we already know how to do. On the contrary, a significant amount of effort is needed to prove technical feasibility of new ways and means of meeting requirements, and to develop new knowledge and understanding of nature. Also, a majority of our problems are system-wide in their implications, rather than related to a particular component or class of components within the system.

The second point is that the aggregate effect of the great sweeps of science and technology is tremendous. Radical changes must be expected and accepted. They may be surmounted only by the summation of alert, sure-footed, and courageous action by each of us in his own field of interest. On the basis of the power industry's record, its part of this assignment is in very good hands indeed.

Striking as these examples of change in our own very basic industry are, they make up only a part of the total picture. In the general scene, it is to be expected that every nation probably will strive to do two things: freely exploit science and technology for the benefit of its people and, at the same time, maintain its national integrity. This integrity should embrace not only the geographical area and resources of a country, but also the total of a nation's established "institutions," including its economic and political ideologies and its standards of value. It is unrealistic and dangerous to assume that all institutions can remain rigid while science and technology are exploding. This assumption is particularly dangerous, because there will always be evil forces within any ideology ready to exploit scientific and technological change.

OUR INSTITUTIONS AND VALUES

TAKING UP THE TASK of looking candidly at some of our institutions and values in the United States, we can certainly say that traditionally we have been the outstanding leader in exploiting science and technology for the many within our hard-won concepts of freedom and the dignity of the individual. We have most certainly demonstrated great courage, ingenuity, and capacity for hard work. But it is important to recognize that our success has also been uniquely dependent on our great natural energy and materials resources and on the favorable position which has permitted standardization and mechanization for mass markets. We tend to be smug about our record in comparison with the countries of Western Europe. We forget the fact that their natural energy and materials resources are restricted, and that they have not developed along the lines of mass production primarily because they are hampered by boundary restrictions which have limited the development of mass markets. They are by no means lacking in courage or ingenuity or hard work.

If we want to see where a major challenge lies, we have only to look to the East and see the parallels there with our own situation. The Soviet Union, China, and India, in contrast to Western Europe, have abundant resources, great potential for industrialization, and enormous mass markets at hand, with no border restrictions to trade. The Soviet Union now has very significant industrial strength and is growing rapidly, through the contributions of highly competent scien-

tists and engineers. Countries that typify this growth include Brazil in South America, as well as China and India. They can be expected to become industrialized powers in the next decades.

Although the United States has led in the exploitation of science and technology, we have not led in their generation. I do not cite this as a failure on our part, but I do mean to point out that we have chosen not to emphasize the kind of individual thinking in depth which produces the "milestone" contributions to understanding and knowledge.

Then there is the matter of coupling with scientific and technological progress. You have only to visit abroad—including the USSR—to find that scientists and engineers in every country are familiar in great detail with our achievements in science and technology. Whatever their native tongue, they follow and appraise our work closely in their field of interest, regardless of how much their requirements, conditions, and standards of excellence may differ from ours. By comparison, we are inclined to be insular in our relationships with world science and technology.

APPROACHES TO TECHNICAL PROBLEMS

EVEN THE MEANS of doing technical work has its contrasts. We have stressed the experimental approach to design and have tended in many fields to neglect the theoretical. Our competent colleagues abroad, for example, choose a design on the basis of proof by calculation—experimenting only to verify critical points. We tend to modify the old, to build one or a number of models, test, change parameters, test again, etc., in order to choose a design. Both methods have their advantages, but our favorite is generally more costly in facilities and time.

Finally, we carry multiple approaches to the same end result far beyond the point where the most promising approach should be selected and the others weeded out. We do this much too often; our friends abroad say frankly they cannot afford it.

We clearly face some challenges in adjustments to change in this whole matter of our relationships to world science and technology.

To go on with our self-examination, the United States today still has unquestionable, world-wide industrial leadership, but what are our plans and objectives with regard to it? We are advocates of self-help for less-developed nations. We are champions of competitive enterprise. But aren't we still very much inclined to insist on our own terms in these matters? In an article in the *Saturday Review* of January 18, 1958, C. B. Randall highlighted our difficulties with respect to activities of the USSR, as follows:

"Soviet bloc tradesmen are everywhere these days. One by one they are attacking key areas, sometimes in Asia, sometimes in the Middle East, and now in Africa and South America, as they scent promise of success.

"They have many trading advantages. They have no hesitancy, for example, to sell below cost, if by so doing they can advance their political objectives. They are willing to extend long-term credits at interest rates as low as 2 per cent. The machinery and equipment which they offer lacks chrome, but is rugged and simple to operate, and is often better suited to conditions in primitive areas than ours. By way of payment, they are willing to accept the foods and fibers which are the only exports which many of the new countries have. This we cannot do, because we already have enormous surpluses of those very commodities.

"When it comes to recruiting trained engineers and technicians who will take up residence in the far-off places of the world to train the local workmen, the Soviets have no problem. Ivan goes where Ivan is sent. And when he goes he speaks the language."

The challenges Mr. Randall speaks about do not stop with business and industry. Their impact comes right on through to you and to me—as members of the working force, as purchasers, as citizens. If we were to draw a moral, I would put it this way: If science and technology can fill a particular need or want of people, that particular need or want will be filled. If this does not happen sooner by our classic methods of free enterprise, it will inevitably happen later and in other ways.

EDUCATION

ANOTHER OF OUR INSTITUTIONS which is feeling the impact of science and technology is education. When the hysteria of the present moment subsides, we shall still have to face this challenge: we must concentrate on quality.

Pursuing our democratic principle of universal schooling, we have measured results in terms of quantity, neglecting qualitative measurements. Now we must face the plain truth that European standards are higher than ours. The qualifications of European graduates when they end their formal schooling and receive their first professional degree would compare with the qualifications of our best students between the master's and the doctorate degrees in our leading schools. Our high school graduates do not match the high school equivalent in Europe.

Salvation does not lie in elevating one branch of learning above another. Millions of dollars for scientific education is not the answer, or millions for the humanities. Whenever I hear someone say that scientists and engineers need more of the humanities to broaden their perspective, I say "I agree." Whenever I hear someone say that liberal arts people need more science and technology in their perspective, I wonder whether I have heard correctly, since this statement is made so rarely. Our goal must be more men and women of broad perspective, as well as a goodly number trained in great depth in the wide gamut of disciplines pertinent to our society.

With respect to undergraduate courses of study, the great growth and change in science and technology indicate that we should not press upon the 4-year man any premature choices of his field of interest. Greater

emphasis on fundamentals common to all fields of engineering and de-emphasis on courses dealing with present equipment or practice seem to be vitally necessary. Trained this way, the 4-year man is more versatile and able to enter various fields of practice. Once he enters a particular field, he will be well prepared to do two things: first, to pick up what specialized training he needs on the job; second, to bring a balanced perception to bear on the past practices which have been developed in that field. Most important, we will not have forced upon him a choice between, for example, power and communication—perhaps resulting in his own frustration and a loss to total progress.

Developing competent manpower calls for inspired teaching, and to attract good teachers, more money is needed. Speaking generally, brick and mortar are secondary. The cost may seem high, but only on our present scale of values. We simply must be prepared to use more of our national wealth for this purpose, and less for purposes not so important.

We could examine other facets of our society, but I am convinced we should, in every case, reach this conclusion: To absorb the impact of science and technology requires of us new values and a new perspective for old values.

We have in the United States the potential "softness" of great wealth. The citizens of this country are accustomed to an extraordinary spectrum of goods and services. We have never had to deny ourselves anything in order to meet national goals, except in time of war. Even then our restrictions have been light indeed, compared with those of others.

This means that our lives include some nonessentials. Much more importantly, it could mean that our standards of value do not recognize what the essentials are. It could mean that we have not had enough of the character-building experience of putting first things first. I submit that matters of the spirit and of the intellect must become more important elements in the fabric of our society.

This brings us to the core of the matter for us in the United States. Granted that we sincerely wish to see scientific and technological progress shared by all the peoples of the world, how do we cross nationalistic interests to bring this about? How do we, a democracy, preserve our precious balance between the value of the individual and the needs of the group when we are dealing with nations whose ideologies permit them to be quite single-minded about the group, with no regard for the individual? How do we make free enterprise an effective participant in world affairs where the monopoly economies of rigidly centralized governments are to be reckoned with?

To maintain the dynamic balance in national and international affairs will require an enlightened citizenry, thoroughly aroused to the urgencies of our time. That citizenry must be prepared to submerge individual interests in the group interest and to orient to new values when and as necessary. It must do these things voluntarily, yet in constant watchfulness over fundamental liberties and values. This democracy must do, because it is absolutely essential that democracy take the initiative.

Can the citizens of a democracy be aroused short of war? Can we be continually aroused to the challenges which face us? Norman Cousins' brilliant editorial "Checklist of Enemies," which appeared in the July 27, 1958, *Saturday Review*, identifies some cardinal threats to this hope.

The first threat is selfish, short-sighted aims. In Mr. Cousins' words: "The enemy is many people. He is a man whose only concern about the world is that it stay in one piece during his lifetime . . . He is an enemy because nothing less than a passionate concern for the rights of unborn legions will enable the world to become connected and whole."

The second threat is hopelessness. Mr. Cousins goes on to say: "The enemy is a man who not only believes in his own helplessness but actually worships it. His main article of faith is that there are mammoth forces at work which the individual cannot possibly comprehend, much less alter or direct. And so he expends vast energies in attempting to convince other people that there is nothing they can do . . ."

THE INDIVIDUAL'S RESPONSIBILITY

How can we overcome these threats? Surely, if we as free men can be stirred to action we, no matter what our position in life, can bring our influence to bear constructively.

First, we must not only learn to accept change; we must assimilate it into our thought patterns. Second, we must remember it is all people who are to share—now and in the future—in what we make of the world. Third, we shall get nowhere unless we concentrate on "Me" not "They." Specifically,

I must keep informed for myself.
I must think out, then choose, objectives to support.
I must reduce those objectives to terms of practical actions, appropriate to my sphere of effort.
I must then act in those terms.
I must observe the results of my actions and adjust both my actions and my objectives in the light of what I learn from observation.

The opportunities to contribute will vary widely among individuals, as will the contributions themselves. The vital point is that everyone must contribute both in perception and in performance. He who does not can also be an enemy.

As Mr. Cousins sums it up, "The enemy is not necessarily a bad man—indeed, he may be a man of high character and considerable good will. He may be giving the best that is in him to his family and his work. But he is a dangerous man nonetheless because he is a chronic absentee from his main job. His main job is to become supremely aware of and intimately involved in the great issues of his time."

Dielectric Strength and Voltage Life of Polyethylene

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AMONG the most promising types of material for insulating high-voltage cables are those in the polyethylene family. Since its introduction around 1940, polyethylene has been used successfully for submarine telegraph and telephone cable, for high-frequency coaxial communication cable, and for multiconductor control cables. It has also been used, in increasing quantities, for high-voltage cable. Its application in 5,000-volt circuits has been accepted by the Insulated Power Cable Engineers Association for some time, and present IPCEA ratings extend to 15,000 volts. There are appreciable amounts of 15,000-volt polyethylene-insulated power cable in use, both in this country and in Europe. Beyond this, there are scattered installations for systems up to 34,500 volts, and manufacturers expect to push the limits even higher.

Many factors can affect service life of insulation. Ambient conditions, type of installation, current loading, and other external factors contribute to the behavior of the cable. There are also properties intrinsic to the cable itself which enter the picture; design and construction of the cable and the voltage–life characteristic of the insulation are basic factors which may control the life of cable in operation. Evaluation of this last property, the a-c voltage vs life characteristic, is the purpose of the tests reported here.

In addition, the opportunity was taken to determine dielectric strength of each of the insulating materials used in the life tests.

In order to reduce the number of variables affecting results, all work was done on wire with a single conductor size and insulation wall. The conductor in all cases was No. 9 AWG solid untinned copper. A 0.100-inch nominal wall of insulation was used.

Various types of polyethylene insulation of a number of different grades and formulations were selected. These include both conventional and high molecular weight polyethylene, and polyethylene to which a number of possible contaminating materials have been added.

Sixteen samples of wire insulated with each compound studied were immersed in water at room temperature. Four of each were subjected to each of four different 60-cycle a-c voltages, corresponding to average stresses of 60, 84, 95, and 125 volts per mil. After several months on test, it became obvious that the time to failure on 60 volts per mil would be too long to be reached for any practical purposes. Accordingly, the test voltage was increased to 144 volts per mil.

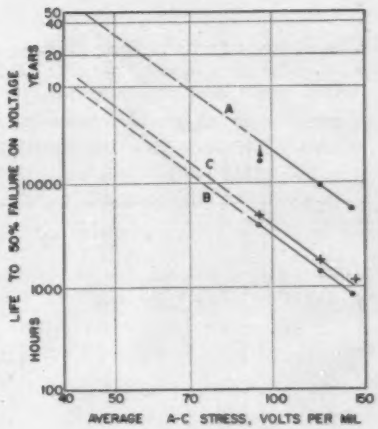

Fig. 1. Voltage life of polyethylene in water. A. High molecular weight; B. Low molecular weight; C. High molecular weight with carbon black.

In order to obtain a statistical picture of the dielectric strength of the materials, 15 samples of each material were broken down under each of the following conditions:

1. A-c quick-rise strength
2. A-c step-rise strength
3. D-c quick-rise strength
4. Impulse strength

Results of voltage–life tests made by grouping similar base materials are shown in Fig. 1.

CONCLUSIONS

1. High molecular weight polyethylene can be expected to have a voltage life about seven times that of standard low molecular weight polyethylene.

2. For any one type of base polymer, contamination of the polyethylene with dirt will materially shorten life on voltage.

3. The addition of carbon black will reduce the voltage life of high molecular weight polyethylene to a value not much higher than that of standard polyethylene.

4. Addition of 5% of Butyl rubber has no significant effect on voltage life.

5. The presence of voids will reduce the initial step-rise strength of polyethylene as compared to its quick-rise strength, but this effect may not shorten life on voltage if water is permitted to permeate into the voids.

6. Extrapolation of the voltage–life curves in Fig. 1 indicates that high molecular weight polyethylene may last (to 50% failure) more than 40 years in water at operating stresses up to 45 volts per mil.

Digest of paper 58-51, recommended by the AIEE Insulated Conductors Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Power Apparatus and Systems*, Apr. 1958, pp. 25-28.

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Today's Challenge to Engineering Initiative

J. K. HODNETTE
FELLOW AIEE

Our profit economy requires, for continued expansion, a progressive lowering of unit production costs that can be translated into lower prices. This means improved technology and a righting of the balance between wages and prices.

I WOULD LIKE to talk on "Today's Challenge to Engineering Initiative." After giving the matter considerable thought, I have begun to realize what a very big subject it is. I have just about concluded that one of the troubles with the United States today is an overproduction of challenges to engineering initiative. In fact, there seems to be almost as many challenges as there are engineers.

The great responsibility that engineering and engineers face is the serious challenge I want to discuss.

This nation has had 19 years of sustained economic growth. Three tremendous waves of industrial expansion have taken place since 1940, and in these expansions we have virtually laid down a new industrial base for our economy.

During World War II, we very nearly doubled our gross national product (GNP). Then came the spurt of expansion in the first five postwar years. This was followed by still another spurt beginning in 1950, at the time of the Communist invasion of Korea. Since then, we have raised our manufacturing capacity more than 50 per cent.

Today, as a result of this massive effort, we have a vastly expanded production capacity in almost every industry and for virtually every product and service. Our economy is now faced with the problem of adjusting to these large additions to productive capacity.

There is nothing new or strange about this. We faced a similar situation in 1949 and in 1953. An economy which is expanding and dynamic, as opposed to one which is merely static, will always face such problems at recurring intervals.

In the past, we have taken care of expanding production with a secret economic weapon. First, we have raised the productivity of our working people with better machines, better equipment, and better, more efficient, methods. In doing this, we have lowered the unit cost of what we produce. We have passed on much of this lowered cost to the consuming public in the form of lower prices.

The results of this classic American economic formula have been threefold. Through most of our history we have had rising real wages. We have turned out greater and greater amounts of vastly improved low-cost commodities and services. And we have created the American mass market to absorb this increased production.

BENEFITS UNEVENLY DISTRIBUTED

HOWEVER, we now seem to be operating on the new principle that the benefits of productivity gains shall be wholly converted into increased wages without consideration of the other contributing factors. Proper reflection is not being given the contribution of engineering, advanced mechanization, or the investment that is required for these gains. Not only does this adversely affect the manufacturer but, for the first time in our economy, the benefits of improved technology are not being passed on to the consumer in the form of lower prices. The benefits are going, instead, to specific groups in the economy in the form of higher dollar wages. These productivity wage increases go first to the workers in larger mass production companies, but, of course, they soon spread to the smaller firms. Large or small, strong or weak, the firms must raise their prices to meet these increased costs if they are to stay in business. Thus, the danger of pricing a product out of the market is created without being able to afford the necessary technical advances.

This situation works against the conditions which have always been considered necessary for full employment and a sound prosperity in this country—namely, a proper relation between prices of different kinds of goods in a free market economy and production costs as well as wages and prices. It is this situation which has produced the strange imbalances we see in the economy today. Wages and prices have been hitting new high points at a time when employment, sales, and profits have been dropping. This statement bears repetition—wages and prices have been hitting new high points at a time when employment, sales, and profits have been dropping. This is contrary to the law of supply and demand, and obviously it cannot continue for very long.

MAJOR ENGINEERING RESPONSIBILITY

THE MAJOR ENGINEERING RESPONSIBILITY mentioned earlier is concerned with this situation. It lies in the

Essentially full text of an address delivered before the AIEE East Central District Meeting, Huntington, W. Va. May 13-15, 1958.

J. K. Hodnette is executive vice-president of the Westinghouse Electric Corporation.

work that must be done—the steps that must be taken—to meet and reverse this trend.

Basically, this is a responsibility—a problem—of industrial management rather than of engineering. And, basically, the solutions must be found in several parts of the economy at once. The attitudes of the labor unions, the actions of Government, the consent of the consumer—all these and other factors have a bearing on how successfully solutions are found to the problems that come with rising costs and falling profits.

Industrial management, nonetheless, will call on engineering to provide a very large share of the total solution. Engineers will be expected to perfect still more efficient machines and still more efficient production methods.

Management must now, as never before, use improved machines and fresh methods to bring unit production costs still lower. It must struggle to translate these lower costs into lower prices. If this can be done, sales volume will rise and production lines will stabilize. The trend to declining profits may be reversed or, at least, contained. The standard of living will continue to improve.

It is the engineering and scientific function of our economy, more than any other, that can help management to accomplish these ends.

This may sound like a pretty large order for a man who happens to have a B.S. degree and simply wants to earn a living in his profession. And yet, this has been the way it has happened in the past, and it is the way it must happen in the future. When management is required, like De Lawd in the play "The Green Pastures," to "r'ar back and pass a miracle," it turns for help first of all to its scientists and engineers.

Management simply wants more of what has been done in the past—but this time, because of the urgency of the economic situation, management wants it faster. And management knows that it will get what it asks for, because the record shows that not only are we getting remarkable new machines and processes, but also an increased tempo in their application.

KEY ROLE OF COMPUTER TECHNOLOGY

IMPROVEMENT of industrial processes and equipment in the past few years has been tremendous. Each new machine and each new process is a little faster, a little better controlled, a little more nearly automatic than the one before it. Along with this improvement has come tremendous progress in a very short time in analog-type feedback control systems and digital-type processing machines. Computer power in the Unitted States is increasing in the ratio of 10 to 1 each year. It is a widely accepted fact of American business life today that no industrial operation can remain competitive without using some form of data processing machine or integral computer technology in machines to provide automatic systems.

As a business friend of mine put it the other day, "Life was simpler in the days of 'Pike's Peak—or Bust.'" He said that one computer manufacturer is thinking of adopting the slogan, "Univac—or Lose the Inside Track." We agreed that this proves, among other things, that slogans are now getting as complicated as our machines.

You may have read the statement in *Fortune* magazine several months ago on what the large computers at Sharon, Pa., are doing in the design of transformers, generators, and motors. These machines perform basic design work in minutes, a task which formerly occupied an engineer for weeks. In designing this kind of electrical equipment, many variables can be used. There is a choice of several combinations to achieve the same performance—and the choice is not an automatic one. The choice, in fact, may mean the difference between a profitable and a losing operation. The computer gives a choice of nine designs in nine minutes. A good engineer doing the same job would be lucky to work out one possible design in two weeks.

These computers are doing more than merely speeding up and improving the design of major products. They are doing tremendous things to the design of engineering itself. By relieving the engineer of tedious chores, such as time-consuming calculations, repetitive application of alternatives, the computers are channeling brainpower into areas of original concepts, basic decisions, brand-new thinking on tough problems.

FUTURE OF THE OHIO VALLEY

MANY OTHER EXAMPLES of striking engineering and scientific developments can be cited. They would all be different, but they would all be linked by a common denominator. Each is an answer to a challenge that faced the engineers and scientists involved. In all cases, the challenge in its broadest terms was simply to produce better products more efficiently at lower cost.

It is very appropriate that this meeting is being held in the heart of the Ohio River Valley. A few things should be pointed out about what is happening in this great industrial area, because it supports the underlying theme of my discussion.

The Ohio River and its valley played a romantic and important part in the westward expansion of our country. Even in the early days, people along the river did not confine their activities to farming and water transportation. They were many miles and mountain ranges away from the manufacturing centers of the East, and so they looked for the fuel and the raw materials for manufacturers of their own. They began to produce wrought iron and build the fabricating plants to use the iron.

When iron gave way to steel, there was considerable economic dislocation. But many of these pioneer industrialists became steel men—and enhanced their reputations still further. For example, the modern high-speed continuous rolling process for making wide strip and sheet was invented and perfected in one of these mills.

Today, the area is rapidly becoming the industrial heartland of America. In the past 7 years, some $8 bil-

lion has been committed for expanding existing industrial facilities and for building new ones. The Ohio now surpasses the Rhine—Europe's "chemical river"—in terms of chemical plant investment. Nearly three times as much steel and more than three times as much coal are produced along the Ohio River than in the Ruhr Valley.

New plants have been springing up in the Ohio Valley for basically the same reasons that prompted the pioneers to establish theirs: abundance of fuels and raw materials. Aluminum, for instance, needs tremendous quantities of low-cost power. For that reason alone, many early aluminum reduction plants were situated in remote places to be near sources of hydro-electric power. As hydro sites became harder to find, the industry turned to low-cost steam generation. The Ohio Valley coal and water, together with today's efficient steam turbines, added up to the right combination for Kaiser Aluminum, with its new plant at Ravenswood, W. Va.; for Olin Mathiesen, at Clarington, Ohio; and for Alcoa, at Evansville, Ind.

For the vast new chemical industry, the abundance of salt deposits in this area was a key factor, although other factors, such as coal, water, space, and electric power had its influence, too. The roll call of chemical companies which have built or are building plants in the Ohio Valley is an impressive vote of confidence in the future of this area.

There is every reason to believe that the industrial build-up in the Ohio Valley still is in its infancy. A substantial portion of the future national expansion of heavy industry will certainly be drawn to this region. And you have yet to see the influx of secondary industries that should follow the development of primary industry.

IMPORTANCE OF COAL

To a very considerable extent, the continued development and prosperity of this region will depend, as it has in the past, on how efficiently and economically you extract coal, the area's primary natural resource. Industry has a ravenous and ever-growing appetite for coal—and for the engineering knowledge to get it out of the ground and into the furnaces of industry quickly and cheaply.

The record of accomplishment here speaks for itself. In 1936, coal was being produced from underground mines at the rate of 4.4 tons per man-day. At that time, less than 20 per cent of underground production was mechanically loaded. Today, the productivity rate is well over 8.5 tons per man-day—and the man-day is a great deal shorter than it used to be. The continuous mining machine is the rule rather than the exception. Millions of feet of belt conveyors are being used to transport coal from the face of the mine to the surface. Automatic hoists for elevating material from underground are commonplace, and have control systems comparable to those of the most modern building elevators.

But even such developments as these will not be enough to meet the demands of the future. Westinghouse estimates that in 20 years the electric utility industry will be using three to five times as much coal as it uses today. This estimate is made despite the fact that in 1978, one fourth of the nation's installed generating capacity may be in nuclear power plants—a capacity just about equal to the total installations today.

We estimate further that in 40 years, the utilities will be burning at least six to eight times as much as they now use. That is twice as much coal as all the coal being mined for all purposes today.

IMPROVED MINING TECHNIQUES NEEDED

To achieve such increases at low costs—in the face of more difficult mining conditions—will certainly be one of the major engineering challenges in the coming decades. The electrical industry foresees the need for spectacular advances in the techniques of mining coal, particularly in the area of controls and is confident that advances will be achieved.

Fully automatic mine hoists for hauling men, supplies, and production will be common in the future. This equipment will operate deep in the earth at speeds exceeding 30 miles an hour. It will carry huge tonnages and will operate without attendants.

Mining machines will be larger and more complex. They will have automatic controls and drives to relieve the operator of many of the decisions he now makes with present-day equipment. Most of today's electromechanical components will be replaced by hermetically sealed and encapsulated relays and motor starters. These will be of the static type and will use powerful transistors. Such equipment will greatly reduce explosion and corrosion hazards. Because of their static nature, maintenance problems will be all but eliminated.

As can be seen, emerging clearly from these remarks is the fact that there are some very serious problems and a tremendous amount of work ahead. Much has been accomplished, but much more remains to be done.

This is not work for the engineer or the scientist alone. It is not work for industrial management alone. It is work for all forces in the economy, for all segments of the population.

If we Americans are to do the work that needs to be done in the decades ahead, and solve the problems which we will have to face, then we must strive to maintain a balanced economy in which *all* groups and interests profit from our technological advances. Consumers must be given improved products at prices they can pay. The stockholder must be paid for the loan of his money, with good protection and enhancement of its value—this is a must, if the business is going to continue to get him to invest his savings. For his skill, care and effort, the worker must be given his fair share—and no more—of the benefits of technology which grow out of a widespread and costly endeavor carried out by the sweat, brains, and money of many people. The public—the communities in which we work and live—must be assured of a stable dependable business environment.

In the marriage between capitalism and democracy which has produced the marvelous system under which this nation lives, there is a mutuality of interest among all these groups. That which hurts one hurts all. What is given to one at the expense of the others, detracts from the total good.

The directors of Westinghouse, in recent years, have been following the practice of paying one half of net profits to the stockholders of the firm—of whom, incidentally, 32,900 are employees. We have plowed the other half back into modernization and expansion of facilities and into research and development. This practice is in the interest of all groups who have a claim on the company—and most particularly to its employees. The firm asks its employees—and most especially that great majority who are union members—to recognize that their interests are served when the company modernizes and expands, improves its processes and products, and invests in laboratory research and engineering development.

I speak freely of the need for profit because I know, as you know, what the consequences can be where there are no profits, or where they are diverted from many groups to one group. Ghost communities have been seen where the major industry has failed because it could not run a profitable operation. Perhaps, specific companies can be remembered whose profits were drained off to the families that owned them, with little or nothing turned back into the business. Those companies have failed or been absorbed, or they have changed their ways.

I speak freely of the need for profit because I know, as you do, that most of the good things come with profits, and that most of these good things disappear when profits disappear. Our improving standard of living, our community welfare programs, our work in health and education, our industrial growth, our research efforts, our tax revenues, our very national strength and security—all these depend on the profit-making capacity of 4 million or more business enterprises around which our economy is built.

As businessmen, we have the major responsibility of giving a good economic performance. As professional men, we have the major responsibility of developing the technological means by which industry can improve its products and processes to the benefit of the national community.

But as citizens, we have responsibilities that are broader and deeper than this. We must be aware of the economic and social context of our industrial development. We must work to show the nation how it may achieve its essential industrial progress and, at the same time, build a society in which the human mind and spirit can develop.

It is no mere technological paradise that we are striving to attain when 20, 40, and 60 years have rolled by. We are striving, rather, to base a magnificent industrial machine on the human values which make that industrial machine worth running.

If you accept this, too, as your challenge, there is nothing in the world that can prevent us from achieving it.

Circuit Checker

In today's long-range aircraft, hundreds of miles of electrical wiring are required to make the various components function. In the Boeing *B-52* global bomber, for example, miniature cannon connectors are used for connecting and disconnecting electrical circuits quickly.

The male end of the cannon connector shown indicates that the cable contains 30 separate wires. Before meeting inspection requirements, each wire must pass rigid continuity and high-voltage breakdown tests. The new device has been developed for conducting such tests, replacing a time-consuming and laborious hand-probing method.

In using the new device, electrical cables to be checked out are connected to master cables on the cir cuit checker. Power is provided by a Model *411* Hypot connected to terminals at the top of the checker. Each wire in a cable has been given a letter designation. To check the "H" wire, for example, one control knob is turned to the "H" position and the other knob is tried at all other positions on the panel to test for shorts or indications of high-voltage breakdown. This latter knob is turned to the "H" position for checking continuity. If the "H" wire, or any other, fails to pass either test, this fact is indicated by a light on the Hypot unit.

This Boeing Airplane Company, Seattle, Wash., circuit checker has proved highly satisfactory. Its advantages are low cost, simplicity of operation, and reliability.

ECPD Accreditation of Engineering Curricula

C. C. CHAMBERS
FELLOW AIEE

G. F. BRANIGAN

The process of accreditation contributes to engineering education, thus to the profession as a whole, by insuring not only adequate curricula, but also the general improvement of all curricula. The history and operation of the ECPD Education and Accreditation Committee are described.

ACCREDITATION of the engineering curricula of our American institutions for engineering education is the most significant contribution to the development of engineering as a profession. It has provided and continues to provide a practical constructive force to enhance the scholarly characteristics of the truly professional engineer. Catering to the intrinsic desire of every institution to improve, the Education and Accreditation Committee of Engineers, Council for Professional Development (ECPD) gives constructive criticism based on its inspection to the institution, even when the quality of the curricula is well above the minimum for accreditation. Thus, this process contributes to engineering education by insuring not only adequate curricula, but also the general improvement of all curricula.

The quality of the American engineering profession is inextricably bound to the quality of the engineering education offered by our schools. Every engineer, therefore, should be interested in understanding this program.

The activities of the Education and Accreditation Committee are not always understood by the ordinary engineer as well as they should be. Some people have the mistaken idea that this committee attempts to stereotype engineering education, which is contrary to the facts. The committee encourages experimentation in engineering education as the way to improvement and advancement of engineering education to a high professional level.

HISTORICAL BACKGROUND OF ECPD

INFORMATION contained in "The Report of the Investigation of Engineering Education, 1923-29," published in *Engineering Education*, the journal of the Society for the Promotion of Engineering Education, has had a profound effect on engineering education and engineering as a profession. Great credit for that early effort to enhance engineering education is due the two leaders who served as director and associate director of this comprehensive self-investigation of curricula, student personnel studies, students and graduates, admission and elimination, teaching personnel, services, and facilities. We refer to the late W. C. Wickenden, president of Case Institute of Applied Science and the late H. P. Hammond, dean of the School of Engineering at Pennsylvania State College.

The scope of the investigation, as well as the stimulation given to further study of problems which closely associated themselves with engineering education and its professional status, led to closer co-operation of engineering societies in general. The danger that each engineering school would have to be independently accredited by each state for registration purposes and by each society for membership purposes indicated a need for unified action. A meeting of minds representing the technical, educational, professional, and legal phases of engineering brought about the formation in 1932 of the Engineers' Council for Professional Development. The participating bodies were the five oldest national engineering societies (civil, mining, mechanical, electrical, and chemical), the Society for the Promotion of Engineering Education (since 1946, the American Society for Engineering Education), and the National Council of State Boards of Engineering Examiners. In 1940, the Engineering Institute of Canada affiliated with ECPD.

PURPOSES OF ECPD

THE GENERAL OBJECTIVE of ECPD is the development of engineering as a profession. There were four standing committees named to implement a plan of action for the achievement of this objective: (1) Engineering schools; (2) Student selection and guidance; (3) Professional development after graduation; and (4) Professional recognition.

There has been no change in the objective of ECPD from the time of its organization in 1932. Some changes in the number of committees to achieve the objectives have been made with accompanying title changes where it has been thought that the functions of the committee might be better portrayed by a more descriptive title. This has been particularly true of the Committee on Engineering Schools. It was renamed the Education Committee and was so designated in the 1951 report. The title was changed to reflect more nearly its accreditation function, and appeared as the Education

Essentially full text of a paper presented as the report of the National Society for Professional Engineers Education Committee at the NSPE Spring Meeting, East Lansing, Mich., Feb. 13-15, 1958. It was presented following discussions of the Committee which included, in addition to the authors, T. S. Crawford, A. C. Crymble, and J. C. Park.

C. C. Chambers is with the University of Pennsylvania, Philadelphia, Pa.; G. F. Branigan is with the University of Arkansas, Fayetteville, Ark.

and Accreditation Committee in the 24th Annual ECPD Report issued in 1956.

EDUCATION AND ACCREDITATION COMMITTEE

In 1932, when ECPD was organized, 27 states, Hawaii, and Puerto Rico had enacted laws which made registration by an examining board a requirement for the practice of professional engineering. A normal requirement of an applicant was an approved diploma. Engineering schools had been autonomous units, fixing their own entrance and graduation requirements. There was great variation in the quality of graduates, because of inadequate curricula, faculties, and facilities and the fact that some schools granted diplomas for less than the normal four years of academic work. The Committee on Engineering Schools assumed the task of accrediting engineering curricula throughout the United States.

Dr. K. T. Compton of the Massachusetts Institute of Technology (MIT) was the first chairman of the Committee on Engineering Schools. The first visiting committees were formed from a list of 100 selected engineers and educators. The schools furnished statistical data requested by the visiting committees for appraising the quality of their work. During the period 1935-39, committees visited approximately 150 engineering schools and passed judgment on nearly 700 curricula submitted by the schools. The fact that 16 per cent of the institutions inspected were refused accrediting and that 25 per cent of all curricula examined were rejected gives an indication of the thoroughness and courage with which this work was done. These figures also give proof of the high standards set by the committee under Dr. Compton's leadership. Upon his regretted resignation in 1939, the governing body of ECPD was very fortunate in persuading Dean A. A. Potter of Purdue University to succeed Dr. Compton as chairman. Dean Potter's work in engineering educational circles and as a past-president of The American Society of Mechanical Engineers and the American Engineering Council had given him great prestige among engineers of our nation, making him a fitting successor to Dr. Compton. Dean Potter served on the Education Committee of the National Society for Professional Engineers (NSPE) last year.

As with any process whereby judgment must be made on the administration of the institution and its school of engineering (including its curricula, faculty and facilities), ECPD and its committees on Engineering Schools have met with some criticism. The multiplicity of accrediting agencies, the tendency of some of these agencies to put educational procedures into a strait jacket, and the practice of requiring extensive information described by administrators as "unpertinent and impertinent" have caused dissatisfaction on the part of educational administrators. On the whole, it is quite generally believed that engineering accreditation procedures are superior to those of many other accrediting agencies. It is also believed that the strong leadership which our committees have enjoyed has given prestige to our accreditation activities. After Dean Potter, the following prominent engineering educators have served as chairman of the accreditation committee: D. B. Prentice, president of Rose Polytechnic Institute; H. T. Heald, president of Illinois Institute of Technology and presently president of the Ford Foundation; S. C. Hollister, dean of engineering at Cornell University; Thorndike Saville, dean of engineering at New York University; Harold Hazen, dean of the Graduate School at MIT; and now W. L. Everitt, dean of engineering at the University of Illinois.

HOW THE COMMITTEE OPERATES

There are seven regional geographical divisions of territorial United States for efficiency of operation of the Education and Accreditation Committee. Each region's chairman and vice-chairman are held responsible for the activities in their region. They are directly responsible to the chairman of the committee. However, all correspondence relative to the committee's activities will normally be addressed to the secretary, S. L. Tyler, at 29 W. 39th St., New York, N. Y., the headquarters of ECPD.

Upon receipt of a request for an inspection or reinspection, Mr. Tyler sends to the head of the engineering school a set of questionnaires to be completed and mailed to the appropriate persons who are involved in the inspection operation. The maximum term of accreditation by ECPD is for a period of 5 years, therefore periodic reinspections are made at those intervals, if a school wishes to maintain its accreditation. Those who receive copies of the questionnaire are the chairman of the over-all committee, the chairman or vice-chairman of the region, and the inspectors for the curricula under consideration. Usually the chairman or vice-chairman will serve as an inspector for the curriculum in his field. However, it is the present practice to provide continuity and uniformity in the inspection procedure by having the chairman or vice-chairman of the region serve as chairman of the inspecting committee on every visitation made in the region, even if curricula to be inspected are not in the field of either's training. The decision as to which one serves as the chairman for any inspection usually is decided between the chairman and the vice-chairman of the region.

Inspection teams are recruited by the chairman for the institution's inspection from a list of inspectors which appears in the annual ECPD report. These are carefully chosen by the Education and Accreditation Committee from the various fields of engineering on the advice of the education committees of the professional society groups. They are then recommended to the governing body of ECPD, the Council, for final approval. It is apparent that a rather careful screening process is followed in the selection of inspectors of curricula in the various branches of engineering.

On the evening prior to the two days set for the inspection at an institution, the inspection committee is called together to review the questionnaire which has been submitted by the school. Also, any previous actions

taken by visiting committees are discussed. Working assignments are made and a schedule is proposed for visiting the service departments which contribute to the education of engineers, as well as the engineering departments. It is the usual practice to arrange a meeting with the dean or chief administrative officer of the engineering program on the morning of the first day. A time may be set to visit with the president of the institution, and other arrangements for the schedule of operations may be worked out, including a luncheon meeting, if the institution sees fit to extend an invitation. ECPD requests that this be the only entertainment provided for the visiting committee by the institution.

The inspection committee will meet on the evening of the first day to discuss findings of its members. Usually, the individual's particular work assignments may be completed by noon of the second day. The committee should reassemble in executive session at luncheon on the second day for crosschecking findings and to come to an agreement as to strengths and weaknesses and the nature of the recommendations that will be made to the institution. These will normally be reported to the dean and, where desirable, to the president on the afternoon of the second day. The inspection team members are then free to return to their homes.

Each inspector prepares a detailed report of his findings as soon as possible after the inspection and sends it to the committee chairman who combines all such reports into a composite report, copies of which go to the general chairman, the regional chairman and the chairman of the inspection committee. This report contains a confidential statement of observations, facts, and recommendations for action by ECPD with regard to accreditation.

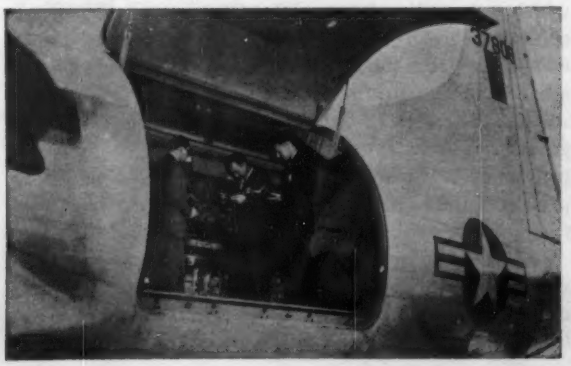
The chairman of the Education and Accreditation Committee calls the seven regional chairmen and vice-chairmen together in June and October of each year to consider reports on institutions of inspection committees. In this way, more uniform treatment is given to the consideration of schools over the country, as a majority vote is necessary to gain support for the recommendations of the visiting committee. However, ECPD has checks and balances for this important work of accreditation. The final approval of the actions of the Education and Accreditation Committee must be received from the Council, which includes three representatives of each of the constituent societies of ECPD. All of the men involved in this work are dedicated to the principles underlying ECPD, development of engineering as a profession through the maintenance of high standards in our engineering schools.

EFFECTS OF ECPD ON PROFESSIONAL AND LEGAL ASPECTS

Recognition of engineering legally as a profession was accelerated by the activities of ECPD and its work in the accreditation of engineering schools. The stumbling block of an approved diploma as a normal requirement for registration was removed. Today all of the 48 states, Hawaii, Puerto Rico, Alaska, and the District of Columbia have laws providing for the registration of professional engineers.

It is hoped that strong support for ECPD and the work of the Education and Accreditation Committee will continue as the profession of engineering advances. An early ECPD publication stated, "Engineering, broadly defined, is the combination of art and science by which materials and power are made useful to mankind." This is still an excellent definition. More emphasis is being placed on science in the engineering curricula of today than on the art of yesterday. It is a transition necessitated by advances in our technolgy. The Education and Accreditation Committee of ECPD accepts as its responsibility the improvement and safeguarding of engineering educational standards by accrediting only those curricula in engineering worthy of recognition.

Transistorized Bombing and Navigation System



New version of Tradic, transistorized electronic brain for automatic bombing and navigation is shown being checked at Morristown, N. J., by some of the Bell Telephone Laboratories engineers who designed and built the electronic system. This system resulted from one of the earliest applications of transistors for the U. S. Air Force to airborne digital computers.

The basic principles of Tradic were applied to a computer which developed into the first all-transistor bombing and navigation system available to the Air Force. It also includes partially transistorized radar; encoding, decoding, and decimal display devices; the plane's instruments; and navigational equipment.

Frequency Response of a Nonlinear Closed-Loop System

W. A. STEIN
MEMBER AIEE

G. J. THALER
MEMBER AIEE

THIS ARTICLE PRESENTS two general concepts which are very valuable in analyzing nonlinear servomechanisms. A graphical procedure is introduced by which the frequency response of a nonlinear closed-loop system can be determined from the describing function. The theory is even valid for the general describing function which is both amplitude and frequency dependent (Fig. 1).

The total transfer function G of a servomechanism can be resolved into the product of two components: $N(j\omega,V)$ which is the describing function of the nonlinear element, and $H(j\omega)$ which is the transfer function of the linear elements. A plot of $H(j\omega)$ and $-1/N(j\omega,V)$ is then made on a gain vs phase-angle co-ordinate graph. The $-1/N(j\omega,V)$ curve is then the locus of the critical points.

These curves may then be used with a Nichols' chart to compute the frequency response of the system when the test signal has a fixed input amplitude R. The procedure involves some trial and error, and is as follows: select any frequency, such as $\omega = \omega_3$. This frequency is to be used on both the $H(j\omega)$ and $-1/N(j\omega,V)$ curves. Since the $-1/N(j\omega,V)$ curves contain a number of points at frequency ω_3 (caused by amplitude-sensitivity) an intelligent estimate of V must be made and the corresponding ω_3 point located.

Assume $V = V''$. The point on the $-1/N$ plot corresponding to ω_3 and V'' is pinpointed over the origin of a conventional Nichols' chart. A value of closed loop gain M and a value of closed loop phase shift ϕ are then read off the Nichols' chart contour lines at the point where $H(jw)$ is equal to ω_3.

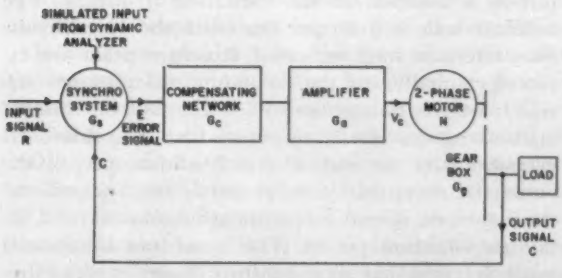


Fig. 1. Block diagram of servomechanism.

It is then necessary to check these results against the assumed value $V = V''$. If a check is not obtained, the procedure is repeated until it does, but convergence is usually very rapid. The entire closed loop frequency response for a specific input amplitude R can be obtained by repeating these calculations at a number of frequencies.

In Fig. 2 the negative reciprocal of the describing function and the transfer function of the remaining

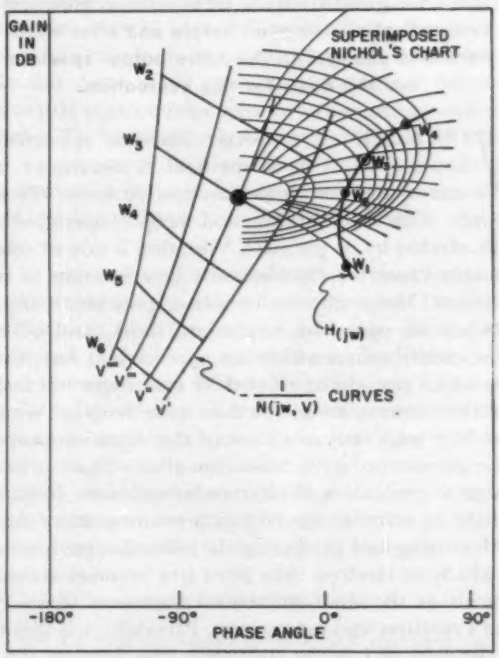


Fig. 2. Graphical construction for determining points on the frequency response characteristic.

linear elements are sketched on the gain vs phase-angle chart. A Nichols' chart is superimposed at the critical point ω_3 and V'''.

Second, an analytical method is developed for evaluating the describing function by Fourier analysis of that type of nonlinear component whose time constant and gain vary with the magnitude of the input signal. As an example of a nonlinear element which meets these specifications the 2-phase servomotor was selected. The closed-loop frequency response was then predicted by the graphical method and verified experimentally.

Digest of paper 58-84, "Obtaining the Frequency Response Characteristics of a Nonlinear Servomechanism from an Amplitude- and Frequency-Sensitive Describing Function," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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Electron Tube Evaluation for Guided Missile Applications

H. G. CHANDLER

Excitation of a tube resonance for prolonged periods has proved a valuable aid in evaluating tubes for guided missile applications. Electrical and optical examination before and after vibration, and changes in the noise output spectrum are the basis for this evaluation.

VIBRATION is a specter that has appeared to haunt most of us in the field of electronics, and one of the areas most susceptible to its effects is electron tubes. Reliability and proper operation are both affected by its presence. Vibration is not, of course, the only cause for electron tube deterioration or malfunction. Many effects—humidity, pressure, temperature, circuit operating conditions, shock, and others—make contributions which are appreciable. Any discussion which considered all of these environmental factors and their interrelation would be quite lengthy. We will deal here with only one facet of the vibration problem —the selection of a vibration test that will assist in the design or evaluation of electron tubes for use in guided missiles or other severe vibration environment vehicles.

Measuring and predicting the vibration environment in which an electron tube must live becomes almost as difficult as the simultaneous measurement of an electron's position and momentum. Particularly is this true in the field of missiles and projectiles, because the environment is usually destroyed during the act of measuring it.

Attempts have been made to record on tape the vibration characteristics of some missiles, and to use this recorded information to drive vibration exciters in the laboratory to simulate field operating conditions. It must be appreciated that every tube socket in a missile will see a unique environment because of its mechanical or structural position. Also, each missile must be considered unique as to the vibration spectra which are generated therein. If multiple missile flights were feasible, then each flight would necessarily be considered unique.

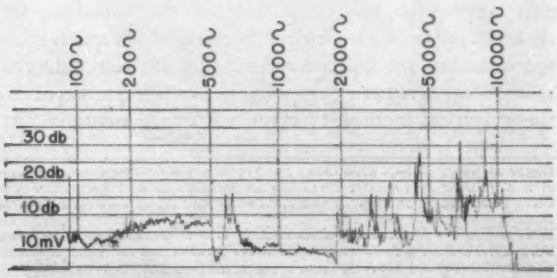


Fig. 1. Typical vibration output spectrum.

The use of such recorded information as a general test, then, must be considered an arbitrary choice of a test environment. The validity of such a choice must certainly be the responsibility of those selecting the type of test. It is not my purpose to quarrel with the type of vibration environment which may be selected as a tool to be used in a particular study, but rather to invite your attention to the fact that the choice of any environment is, at best, an arbitrary compromise.

EVALUATION TEST

ON THIS BASIS the single-frequency high-acceleration test was selected for electromechancial evaluation of subminiature receiving type tubes for guided missile fuze applications at DOFL (Diamond Ordnance Fuze Laboratories of the United States Army). At present, the test is constituted as follows: Tube-under-test element voltages and circuit constants are as specified in *MIL-E-1C* as far as practical. The excitation frequency is varied automatically from 100 cycles to 10,000 cycles per second on a logarithmic scale during a sweep period of approximately 2 minutes. Excitation at the tube is maintained constant during the sweep at 15 g (acceleration of gravity), and the noise component of anode current is recorded as a voltage on a db scale. Fig. 1 is a typical record, showing noise output as a function of the excitation frequency. The ordinate scale is 5 db per line, with the 10 millivolts (mv) reference level indicated. Resonant peaks are explored manually, and the maximum tube output excitation frequency is determined. The tube is then vibrated at this frequency for 30 minutes with a 15-g sinusoidal excitation. At the end of this 30-minute period, the automatic sweep and manual search are repeated and the maximum output frequency again selected for a 30-minute vibration period. This procedure is repeated until the tube has received three hours of single-frequency 15-g vibration at its maximum output frequency, or until catastrophic failure, whichever occurs first. Our previous experience has indicated that three hours is an optimum time limit for this type of test. In general, the additional information obtained from protracted testing does not appear to warrant the cost. This is particu-

H. G. Chandler is with the Diamond Ordnance Fuze Laboratories, Ordnance Corps, United States Army, Washington, D. C.

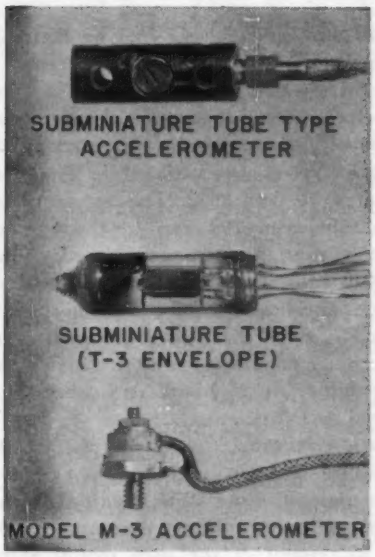


Fig. 2. *M-3* and *T-3* type accelerometers.

larly true where we are not too much concerned with long-time reliability under severe vibration environments.

Deterioration of the tube, or the lack thereof, as indicated by changes in electrical characteristics or output noise amplitude materially assists in the comparative evaluation of similar tube types. Significant differences between manufacturers of a given tube type may also be disclosed.

Differences in the rate of increase of noise with time, or in relative noise amplitudes at a given time may indicate poor initial element fit or wearing away of the micas at points of contact. Progressive deterioration of welds or incipient mechanical failure of materials such as open cathode tabs or cathode ribbon may also be disclosed by these indications. Workmanship or design which leads to early catastrophic failure such as opens and short circuits may be quickly detected. Changes in electrode spacing, flaking of cathode material and mica spacers, and breakdown of heater insulation may result in significant changes in electrical characteristics.

Information obtained by this procedure has also proved valuable in uncovering structural weaknesses within the tube, as will be discussed later.

The exciter used in this program was developed at DOFL specifically for subminiature tube vibration studies. A detailed discussion of this work is given in DOFL Technical Report No. *TR-102*, "A Flat Vibration-Generator for Microphonic Investigations," by J. D. Rosenberg. With the proper mechanical damping and driving circuitry, the acceleration-frequency curve is flat within $\pm 20\%$ from 100 to 10,000 cycles at 15 g. To insure further the constancy of the excitation to the tube, the signal from a Model *M-3* barium titanate accelerometer, stud-mounted near the tube under test, is fed back to an agc circuit in the automatic sweep frequency generator. This permits holding the acceleration level constant within one or two db.

Fig. 2 shows the Model *M-3* barium titanate accelerometer which was developed at DOFL prior to the subminiature vibrator development and which aided materially in this work. Also shown is a *T-3* accelerometer designed to have the same physical dimensions and mass as a subminiature tube and can physically replace the tube in the vibrator or in a missile or missile fuze being vibrated. The *T-3* accelerometer was developed at DOFL in conjunction with the vibrator development work. Fig. 3 illustrates the type of vibrator used in this work. Note the Model *M-3* accelerometer mounted on the vibrator head very close to the tube under test.

The proximity of the *M-3* accelerometer to the tube under test should be noted particularly. Flexures and resonances of a body or surface can be the cause of considerable error when relating a transducer output to the actual environment seen by a component under test nearby. To be completely honest, we should be using a *T-3* accelerometer in place of the tube to monitor the acceleration level seen by the tube. This being impossible, we locate an *M-3* as close as possible to the tube under test.

The seriousness of this problem and need for caution is illustrated by the following experience. During the development of a fuze amplifier circuit, the engineers attempted to run a 5-g sweep frequency vibration test on a prototype unit. When the exciter was adjusted to give a 5-g drive measured at the vibrator table and a frequency sweep attempted, the tubes failed miserably. Substituting a *T-3* accelerometer for one of the tubes disclosed that the tube socket was actually seeing as much as 85 g at some frequencies, because of the mechanical amplification of the amplifier chassis.

TEST CONSIDERATIONS

Some of the considerations which dictated the frequency and g level limits may well be discussed at this point. Although there appears to be little factual information on which to base it, the engineering consensus seems to be that there may well be frequency components as high as 10 kc in missile vibration spectra.

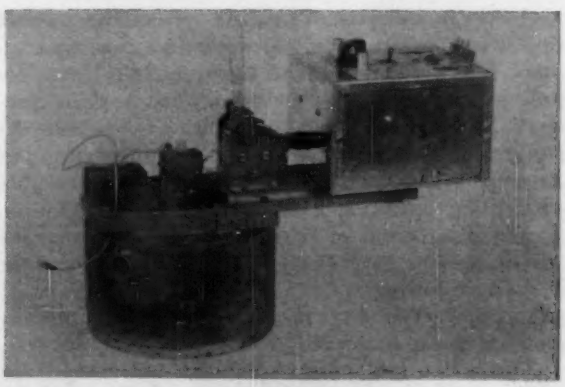


Fig. 3. Subminiature tube vibrator.

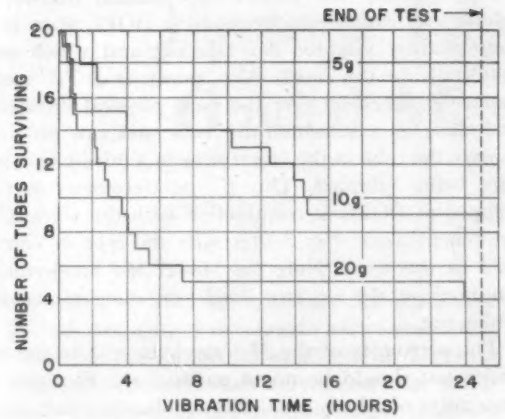


Fig. 4. Tube failure vs vibration time.

The practical difficulties inherent in the design of vibration equipment that will operate satisfactorily at these frequencies are well known, and I can assure you that many a grey hair was attributed to this development work at our laboratories. The lower frequency limit of 100 cycles is arbitrarily selected to minimize line frequency pick-up, and because vibration amplitude becomes excessive at lower frequencies.

The 15-g drive level is nearing the upper limit of the power capabilities of the present exciter and the associated power supplies. This is not thought to be a serious limitation however, in this type of test. Additional power at single frequencies is not believed necessary at this time. As more complete information on missile environments is obtained, modifications to these limits may become necessary.

That the type test just outlined is extremely rugged treatment is not denied. It is justified, however, because it is intended as an evaluation tool, and not as a quality control test. It also has considerable merit as an aid in tube development, in disclosing mechanical weakness that might go undetected under a white noise or low-frequency low-g test.

USEFULNESS OF TEST

A TYPICAL EXAMPLE of how this type of test is useful in uncovering structural weaknesses in a tube type follows: The G.M. Fuze Tube Group at DOFL has, for some time, conducted a "Defective Tube Analysis" program for tubes that have failed during missile fuze development. These tubes are returned to the tube group accompanied by as much information as is available concerning operating conditions, circuit application, etc. Over a period of time, one of the predominant causes of failure was open heaters and most of these had failed during mechanical environmental testing. It was decided, therefore, to attempt to obtain information correlating heater failure with vibration conditions.

Two similar subminiature pentodes were selected for this study. Except for a 150 ma helix wound heater in type *A*, and a 200 ma folded heater in type *B*, these tubes had very similar characteristics.

All tubes used for the study were given a visual inspection and an electrical check before vibration, and only tubes passing *MIL-E-1B* specifications were used. Three 20 tube lots of type *A* were vibrated for 25 hours, or until failure, at 5, 10, and 20 g. The frequency of vibration was that between 100 and 1,000 cycles at which maximum output noise was obtained. This varied from tube to tube, but was generally between 700 and 900 cycles. The heater failure rate for type *A* tubes is shown in Fig. 4. Of the type *B* tubes, 20 were vibrated under the same conditions at 20 g. There were no type *B* heater failures in 25 hours, so further tests were not considered necessary.

Visual examination revealed that each tube which failed had micas whose bumper points were not rigidly pressed against the glass envelope. With sustained vibration, the loosely pressed mica bumpers were pulverized, allowing greater movement of the tube mount. Any loosely held element could then be more vigorously excited by receiving more energy from shock excitation between element and mica. Visual inspection clearly revealed a better mica-to-element fit and a more rigidly held tube mount in the type *B* than in type *A* tubes. The results of this work clearly indicated a weakness in tube type *A* which seriously affected reliability of operation.

This example of single frequency high-g vibration illustrates quite well the value of this type of test when properly used. It does subject the tube to very rough treatment, and for this reason may add something to our safety factor. It is a destructive test and could not, therefore, be considered adaptable in its present form to production line applications, even excluding the very considerable time required per test. Modifications, based on engineering experience, can extend its utility as a tool to be used in the design or evaluation of electron tubes for severe vibration environment applications.

Battery Vest

Development of a battery vest, utilizing human body heat to keep dry cells warm and active for radio operators in extremely cold weather has been undergoing rigorous field tests in Alaska.

The idea, developed by the United States Army Signal Research and Development Laboratory is to place dry cell batteries in a vestlike garment worn beneath parkas to capture body heat.

Thus, batteries developed for low-temperature use are expected to stay in service ten times longer in 40-degree-below-zero weather. Test models were built by Burgess Battery Co., Freeport, Long Island, New York.

The 115-Kv, 1 Million Kva Gas-Filled Breaker

E. B. HENRY
MEMBER AIEE

R. E. FRIEDRICH
MEMBER AIEE

F. L. REESE
ASSOCIATE MEMBER AIEE

A 115-KV CIRCUIT BREAKER of moderate interrupting capacity designed to meet some special and definite applications has long been deemed desirable on the transmission system of the Gulf Power Company. Consequently, when the gas-filled (sulfur-hexafluoride) Type *1150-SF-1000* power circuit breaker rated for 115-kv, 1 million kva service became available, this utility company agreed to purchase three in order to obtain service experience and to permit staged field tests for comparison with test results obtained in the High Power Laboratory.

The *1150-SF-1000* circuit breaker (Fig. 1) consists of three porcelain-clad pole units mounted vertically on a supporting frame to give sufficient height to meet the Safety Code clearance requirement. Each pole unit is composed of two porcelain assemblies that are bolted together. The upper assembly contains the interrupter unit comprised of six simultaneous breaks which are formed horizontally. The lower assembly provides voltage insulation to ground. Each of these pole units contains sulfur-hexafluoride gas at 45 pounds per square inch gauge (psig) pressure.

The first staged field tests on this type breaker consisted of 30, three-phase line-dropping tests on a 50-mile length of line. The charging current was approximately 16 amperes and the system voltage 109 kv. The second line-dropping series consisted of a group of 30, three-phase tests on a 27-mile length of line. The charging current of this length of line was 7 amperes and the system voltage was again 109 kv.

From the oscillograms obtained during the line-dropping tests, it was found that the breaker was completely restrike free in its performance in both series of line-dropping operations. Considering each three-phase operation equivalent to three single-phase tests, only 16% of the opening operations on the long line (16 amperes) involved harmless re-ignitions with pauses in the current less than ¼ cycle duration. The other 84% was completely void of any buildups. Likewise, on the short length of line (7 amperes) only 9% of the operations involved re-ignitions. The interrupting times on these tests did not exceed 2.35 cycles and many were as short as 1.80 cycles on both lengths of line.

The fault test program consisted of three 3-phase bolted faults. The system voltage just prior to these tests was 109 kv and the predicted current was approximately 2,500 amperes or 470,000 kva.

Digest of paper 58-128, "Service Experience and Staged Field Tests on the 115-Kv, 1,000,000 Kva Gas-Filled Power Circuit Breaker," recommended by the AIEE Switchgear Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in *AIEE Power Apparatus and Systems*, 1958.

E. B. Henry is with the Gulf Power Company, Pensacola, Fla.; R. E. Friedrich and F. L. Reese are with Westinghouse Electric Corporation, East Pittsburgh, Pa.

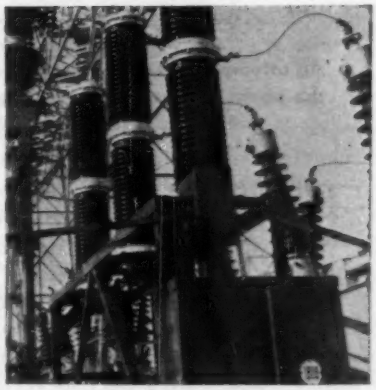
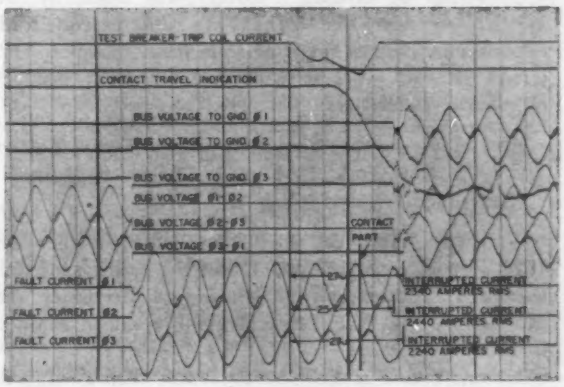


Fig. 1 (right). View of SF_6 test circuit breaker at South Crestview substation.

Fig. 2 (below). Magnetic oscillogram of the fault test. The system voltage just prior to this test was 109 kv. (Timing lines on the oscillogram are 100 lines per second.)



On the oscillogram obtained on one of the fault tests, Fig. 2, the interrupted currents measured on the three phases were respectively, 2,340, 2,440, and 2,240 amperes. The corresponding interrupting times were 2.7, 2.5, and 2.7 cycles. During these fault tests there was no breaker demonstration, as was to be expected, because of the use of a gas medium.

The excellent condition of the contacts, following the aforementioned tests and the several months of service which included two automatic fault clearing operations, was such as to require no maintenance. The record of no appreciable loss in gas pressure in over a year's time since initial installation of the first of three breakers on this system indicated the feasibility of designing such a breaker with gasket seals. The ease of inspection and maintenance of the contacts was demonstrated by the short time required to open up the pole unit, remove the contacts, examine and replace them, and reseal the pole unit.

The over-all performance demonstrated by the *1150-SF-1000* breakers on the Gulf Power System confirmed all expectations based upon results obtained during development in the High Power Laboratory.

Delete John Wood!

R. A. CHIPMAN

An attempt to clear out some dead "Wood" from the early history of electrical conduction placed there by a spare-time historian.

THE HISTORY of the discovery of electrical conduction contains one highly disconcerting entry, which a modern reader is perhaps most likely to encounter in the following version:

"A.D. 1726—Wood (John), an English architect of considerable repute, is said to have shown that the electric fluid could be conveyed through wires a long distance, and, during the year 1747, one of the earliest applications of Wood's discovery was made by Dr. William Watson (see A.D. 1745), who extended his experiments over a space of four miles, comprising a circuit of two miles of wire and an equal distance of ground. References:

> Alexander Jones, "Sketch of the Electric Telegraph," New York, 1852, p. 7; Charles F. Briggs, "Story of the Telegraph," 1858, p. 18.

This paragraph, the only item listed for the year 1726, is from pages 158 and 159 of the painstaking and thorough "Bibliographical History of Electricity and Magnetism" by P. F. Mottelay, published in London in 1922.

No one before or since Mottelay has been as diligent in the encyclopedic accumulation of details of electrical history, and his book is a bibliographical treasurehouse. On the whole, however, Mottelay was not highly critical of his sources, and on specific topics one must be very cautious about his authority.

Taken by itself, his mention of John Wood under date 1726, coupled with the mention of William Watson's work, would imply that Mottelay regarded these as the important revelations on electrical conduction up to 1745. Yet, only five pages previously, he had devoted a long section to the work of Stephen Gray, with full discussion of Gray's achievement in 1729 of transmitting the electrical attraction effect over lines of "packthread" several hundred feet long. Under date 1731, he mentions an evening at the Royal Society when several experiments were performed, including some "On the electrical observations of Mr. Stephen Grey," which "showed the facility with which electricity passes through great lengths of conductors and are worth noting as being the first of their nature." Later, under date 1742, several pages before his main entry on William Watson, he quotes Priestley's description of Andreas Gordon's transmission of electricity over 250 yards of iron wire.

Thus, on at least three counts, Mottelay's "John Wood" entry is in disagreement with other well-substantiated parts of his text. In the light of his constant concern about priorities, the paragraph's off-hand concession of the discovery of electrical conduction to a John Wood who is otherwise unknown to the world of science is particularly incredible.

MOTTELAY'S SOURCES

TURNING TO THE REFERENCES Mottelay offers for his information we find the following:

1. Alexander Jones, "Historical Sketch of the Electric Telegraph," New York, 1852, on pages 7 and 8:

"1726—Wood, of England, discovered that the electric fluid could be conveyed a long distance, by conducting wires.

"1746—Winkler, of Leipsic, discharged a Leyden jar by a friction machine, through a wire of considerable length; and on that occasion the River Pleis formed part of his circuit. (Priestly's History of Electricity, p. 59.)

"1747—Dr. Watson, of England, extended the experiments. . . . (Philosophical Transactions vol. xiv., 1748)."

2. Charles F. Briggs and Augustus Maverick, "The Story of the Telegraph, and a History of the Great Atlantic Cable," New York, 1858, on page 18:

> "In the year 1726 John Wood, of England, discovered that electricity could be conveyed a long distance by conducting wires, and in 1747 one of the earliest applications of the discovery was made by Doctor Watson, who extended his experiments over a space of four miles, comprising a circuit of two miles of wire and an equal distance of ground."

It seems obvious that Mottelay copied his statement, with only slight modification, from Briggs and Maverick. This, in fact, accounts very nicely for his juxtaposing Wood and Watson, which his other material would not lead him to do.

Briggs and Maverick do not specifically attribute their account of Wood to Alexander Jones, but only a few lines after the above quotation they vouch for some information on another topic as being "according to Jones' Book of the Telegraph," and we may therefore be reasonably satisfied that they had no other authority on John Wood.

How did Briggs and Maverick get from the simple "Wood" of Jones to "John Wood," and on what basis did Mottelay further add "an English architect of con-

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siderable repute?" One can only assume that each, in turn, consulted biographical collections and picked out the most likely candidate.

THE REAL JOHN WOOD

IT HAPPENS THERE WAS INDEED a John Wood in the right place at the right time, and one fully deserving of Mottelay's words of praise. He is described at length in the recent "Biographical Dictionary of English Architects 1660-1840," by H. M. Colvin, Harvard University Press, 1954. His birth date is thought to have been about 1704, and he died in 1754. Colvin says "John Wood's early life is obscure but there is evidence that he was living in London in 1725-27." In the latter year, he certainly moved to Bath where he very quickly became one of the best-known architects of his time, chiefly because of his comprehensive planning for that city. Unfortunately, there is no mention that this John Wood ever had any connection with matters scientific, whether electrical or otherwise, and because he was only 22 years of age in 1726 and unquestionably exceedingly busy furthering his career as an architect, it seems most unlikely that he would have been experimenting with electricity at a time when no one else (except Stephen Gray) is known to have been doing so.

Finally then, we are driven back to Alexander Jones as apparently the sole source of the rumor that "Wood" discovered electrical conduction. What weight can we give to the evidence of this American far removed in time and space from the England of 1726?

Jones' sentence on "Wood" is the first of a sequence of several dozen very brief chronological items. It is significant that all of the early items in this list are fully documented, with the single exception of "Wood." This whole chapter of Jones' book is studded with the names of innumerable periodicals of the 18th and 19th Centuries, but this is not to say that Jones must be regarded as a rock of reliability. He confesses in his preface: "We have had to write our work at leisure moments, snatched from other daily occupation, and chiefly during evenings, or at night. We therefore have to crave the indulgence of the reader for such errors as may here and there present themselves."

Jones was aware of the conduction experiments of Gray and Wheeler, and mentions them on the first page of his book. Although he was able to quote volume number and year (incorrectly) for the description of William Watson's work in the Philosophical Transactions of the Royal Society, he could not do the same for Gray, having learned of the latter from a "Life of Franklin" by Stuber. Jones, in fact, does not sound really authoritative about telegraph history until he begins dealing with events that occurred during his own lifetime, and has in front of him the printed evidence and decisions of the numerous lawsuits that marked the pioneer days of the telegraph industry. It appears quite certain that he never personally checked any of his 18th Century references.

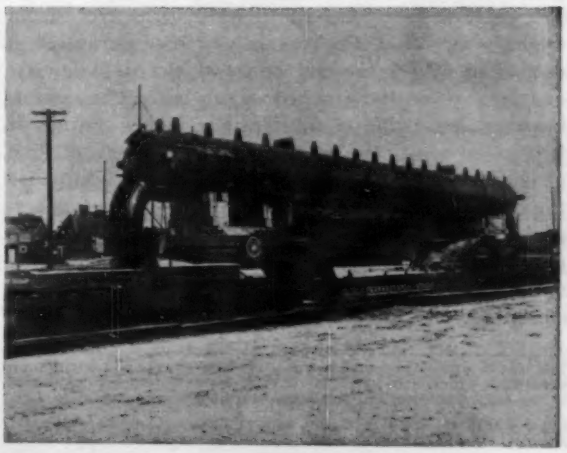
Where then did "Wood" come from? Unless some better evidence for his existence can be discovered, it is a reasonable surmise that he is a faulty recollection of the name "Gray," by a spare-time historian who didn't always remember from one "snatch" to the next what he had written on previous occasions, and who, for these early periods at least, did not care enough to check.

Let us give this dead "Wood" in the history of electrical conduction a decent burial, unless someone can breathe some real life into him.

Nation's Largest Freight Car

The largest freight car in the United States, carrying a 403,500-pound boiler drum more than 78 feet long, stands in the yard of The Babcock & Wilcox Company's (B&W) Barberton Works before starting a 780-mile journey to Tennessee. The drum will be a part of one of three boilers B&W is furnishing for the Thomas H. Allen Electric Generating Station in Memphis.

Property of the Pennsylvania Railroad, the depressed flatcar is 121 feet, 9 inches long, weighs 500,400 pounds and has a load limit of 503,600 pounds. Maximum speed of the car and cargo was limited to 30 miles per hour during the movement, while an empty car, or "idler," was placed at each end of the flatcar to avoid weight concentration. The shipment had an over-all height of 18 feet, 9 inches above the rails, an inch less than the route's maximum height clearance.



Instrumentation for a Boiling Water Reactor

LESTER KORNBLITH, JR.
ASSOCIATE MEMBER AIEE

A description is given of the instrumentation for the Vallecitos Boiling Water Reactor, a small-scale power reactor supplying steam to a turbine operated by the Pacific Gas & Electric Company as part of their generating facilities. An attempt has been made in the design of the plant to keep the instrumentation as simple as possible.

THE INSTRUMENTATION for the Vallecitos Boiling Water Reactor (VBWR) was designed by the General Electric Company (GE) to provide as simple and inexpensive a system as was compatible with safety and with the operational requirements. Since the reactor is intended for use both as a developmental reactor and as an electric power producing plant, the instrumentation necessarily includes some features which would not normally be found in an installation designed exclusively for the production of power. Conversely, the fact that the plant is developmental and is not required to produce electricity continuously allows the designer to dispense with some of the equipment often found in plants designed primarily for continuity of operation. The design described, which resulted from these considerations, appears to meet the requirements.

REACTOR PLANT

THE VBWR is an enriched uranium, light water-cooled and water-moderated boiling reactor. It is enclosed in a 7-foot diameter pressure vessel suitable for operation at 1,000 pounds per square inch. A turbine–generator plant has been provided by Pacific Gas & Electric Company (PG&E) to utilize whatever steam might be available. The reactor is licensed for a normal output of 30,000 thermal or 5,000 electric kilowatts and the turbine plant is sized on this basis. The reactor, however, is capable of substantially higher output. It is planned to run the reactor for short periods of time at considerably higher power by dumping steam into the condenser or by dissipating heat in a steam generator which is provided for simulated dual-cycle operation. All instrumentation, relief valves, and safety devices are designed to handle operating levels as high as 60,000 thermal kilowatts, although it is unlikely that the present core will produce this much power without an increase in size.

Four modes of operation are provided for the reactor. The simplest of these is the single-cycle natural-circulation mode in which water circulates internally, rising through the core and returning through the annular space between the core and pressure vessel to the bottom of the reactor. Steam produced is taken from the top of the vessel, reduced to the rated throttle pressure and fed to the turbine. Exhaust steam from the turbine is condensed, deaerated, and returned to the reactor.

A second mode of operation is the single-cycle forced-circulation mode, in which the space around the reactor is closed off by baffles and water is withdrawn above the core, circulated through an external pumping loop, and returned to the bottom of the reactor. By controlling the circulation rate through the external loop and, thus, through the core, it is possible to control the rate of power production.

The third mode is the dual-cycle forced-circulation mode. This is similar in layout to the single-cycle forced-circulation mode, except that the external loop contains a secondary steam generator. Steam is produced in this generator at a pressure somewhat below the reactor pressure and is normally fed into the turbine in one of the lower pressure stages. In this plant, however, the dual cycle is only simulated, in order to simplify the design and allow use of an available turbine. This simulation is provided by generating the secondary steam at atmospheric pressure and exhausting it to a stack. Although this simulation is not economical of power, it will allow the investigation of the properties of dual-cycle operation. This has never been done before. The dual cycle is intended to increase the power capability of a given reactor core by allowing the extraction of more heat, in the form of hot water, without increasing the steam void fraction and also by lowering the temperature of water entering the core, which increases reactivity and improves heat transfer. Changes in the amount of heat extracted in the secondary loop automatically adjust the reactivity and power output of the reactor by changing the inlet temperature.

Dual-cycle natural circulation is similar to the mode just described except that the baffles around the core are opened to allow natural circulation of water through the core as well as the forced circulation through the external loop.

In addition to the basic plant described previously, the installation includes a clean-up loop, which with-

Full text of a paper presented at the 3rd Nuclear Science and Engineering Conference, Chicago, Ill., Mar. 17-21, 1958. Recommended for publication by the AIEE Nucleonic and Radiation Instrumentation Committee.

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draws water from the lower part of the reactor vessel, purifies it, and restores it to the reactor. An emergency heat exchanger which automatically removes shutdown heat in the event of overpressure in the reactor after shutdown is also provided. This exchanger is gravity fed and is independent of all external power sources. The conventional turbine plant auxiliaries also are included in the installation.

The fuel elements consist of assemblies of plates composed of a core of stainless steel powder mixed with uranium dioxide clad in stainless steel. The "meat" thickness is 0.015 inch and the cladding thickness is 0.005 inch. The uranium is fully enriched and is mixed with the stainless steel powder in several ratios ranging from 20 to 30 per cent UO_2. The plates are assembled into elements by attaching them to suitable side plates and affixing locating tips, chimneys, and handles. Either nine or six fuel plates are used in each element. Thus, a variety of fuel elements are available, having a U-235 content ranging from about 180 grams to 270 grams.

The elements fit into an egg-crate type grid which is suspended by long bolts from a ring located in the upper part of the pressure vessel. A hinged upper grid holds the elements down and locates the tops. Spaces are left between certain rows of fuel elements to allow the insertion of control rods. The seven rods are thin plates consisting of boron carbide clad in stainless steel. They are operated by electropneumatic drives located above the reactor vessel. The drives each consist of a double-ended air cylinder that normally pushes the control rod shaft up against a motor-driven stop which regulates control rod position. To scram the reactor, air is exhausted from the lower part of the cylinder and high-pressure air is applied to the upper part of the cylinder. The motor-driven stop automatically follows the rod down.

NUCLEAR INSTRUMENTATION

TWO START-UP CHANNELS are provided, each consisting of a boron proportional counter, a preamplifier, a linear amplifier with pulse-height discrimination, and a logarithmic counting-rate meter. In addition, a scaler and a recorder which can be individually connected to either channel are provided. The two counters are so located that one is in a neutron flux about 10 times higher than the other. No means is provided for moving the counters remotely, but high voltage is removed when the flux is above the counter range.

Four ionization chamber channels are used. These channels employ identical enriched-boron-lined gamma-compensated ion chambers having a sensitivity of approximately 3×10^{-14} amperes per nv. The gamma compensation is 98 per cent or better and the chambers are designed for high-temperature operation. These chambers, as well as the proportional counters, are located in sleeves through the shielding around the reactor. These sleeves terminate about 6 inches outside the reactor vessel. Inside the vessel, between the chambers and the core, a stainless steel clad aluminum cylinder 12 inches in diameter and 18 inches long is installed to provide a path for the neutrons, as free as possible from the varying attenuation which would occur in a water path as the result of variations in density of the water as a function of temperature. In a long water path, this variation may be substantial and may lead to highly misleading interpretations of instrument readings.

One of the ion chambers is connected to one channel of a 2-channel safety amplifier. High-speed trip circuits in this amplifier scram the reactor at 125 per-cent power. The amplifier is equipped with a meter reading per-cent power. This quantity is also recorded on a strip-chart recorder.

A second ion chamber is connected to a mirror galvanometer and then to the second channel of the safety amplifier. This channel has a series relay set to scram the reactor at 130 per cent of full power.

The third ion chamber feeds a log n and period amplifier. Both log n and period outputs appear on the meters in the amplifier and on recorders and, in addition, a repeater for the period meter is provided immediately in front of the reactor operator. Two additional meters with "contactless control initiators" are provided in the log n output. One of these is an adjustable initiator which is used as a neutron level trip and the other has dual contacts, one being used after the power is in the period meter range to bypass a relay which requires a minimum counting rate, and the second being used to bypass the period meter after boiling starts. The period meter is useless in this range because of the small but rapid variations in flux which occur as a result of bubble formation.

The fourth ion chamber is used to measure neutron level with a multirange micromicroammeter. This meter has full scale ranges of 10^{-12} to 10^{-3} amperes and covers the entire range of operating fluxes. It is also provided with a high-speed trip. A strip-chart recorder with a fast chart speed and 1-second response is connected to this instrument in order to observe the effects of boiling on the reactor output.

Two regulated power supplies are paralleled through a diode mixer to provide high voltage for all of the ion chambers. Provision is made in the mixer to switch the chamber feeding the galvanometer automatically to a battery supply in case of power failure.

The trip circuits from the log n amplifier, the period output, and the micromicroammeter are all connected into the high-speed circuit of the safety amplifier. A secondary trip in the safety amplifier is achieved by removing a-c power from the output stage. The secondary circuit is used as a lower speed scram circuit actuated, among other sources, by the galvanometer relay, low reactor water level, low condenser vacuum, seismological disturbance, high steam flow, and high readings on the area radiation monitoring systems. Many of these disturbances also act automatically to close fast-operating valves which isolate the reactor and its enclosure from the surrounding environment.

The area monitoring system consists of a 5-station

system with ion chambers located in the reactor enclosure, next to the main steam line, in the stack, and next to two of the demineralizer units. A multipoint recorder is provided to record these outputs and is equipped with alarm switches.

STEAM PLANT INSTRUMENTATION

THE NON-NUCLEAR PORTIONS of the instrumentation follow, for the most part, conventional practices. The reactor water level is controlled by a standard 3-element system which measures level and steam and feedwater flow, and derives from these measurements a suitable signal to operate a pneumatic feedwater valve. The three measured parameters are displayed on circular chart recorders. Appropriate compensation is made for reactor pressure. The scale on the steam flow recorder is calibrated for demonstration purposes in equivalent electrical megawatts.

Two additional recorders are provided on the primary steam system. A reactor steam pressure recorder is installed and is equipped with switches to operate a high-pressure alarm and to operate the emergency cooler system. Back-up switches on separate pressure-measuring elements are also provided for these functions. Inasmuch as steam flowing from the reactor may be sent either into the turbine or into the condenser, or both, a separate system is used to measure and record the steam flow to the turbine throttle.

The instruments used for turbine and generator control were laid out by The Pacific Gas & Electric Company to conform to their standard practices. Quantities measured include pressure after throttle valve, turbine exhaust temperature, generator currents, voltages, power and reactive power, condenser vacuum, field and stator temperatures, frequency, turbine speed, and excitation voltage and current. The usual synchronizing equipment is provided.

A resistance thermometer is provided to measure condensate temperature. It is equipped with a "contactless control initiator" to operate a high-temperature alarm to protect the demineralizer resins.

Additional local instruments, including many temperature-, pressure-, and flow-measuring devices, are installed in the reactor and turbine buildings. A closed-circuit television system allows those instruments in the reactor enclosure to be read from the control room.

The operation of the secondary coolant system is monitored by four additional circular-chart recorders. As stated previously, circulation in this loop may be through a secondary steam generator, through a bypass around the steam generator, or through a combination of these paths as selected by remote-controlled motor-operated valves. Two flow recorders are used, one measuring the flow through the steam generator and one measuring the total flow through the loop. A third recorder measures the temperature differential across the loop. A fourth recorder computes and records the product of temperature differential and total flow. This recorder, again, is calibrated in equivalent electrical output. An automatic level control system is also provided for this steam generator.

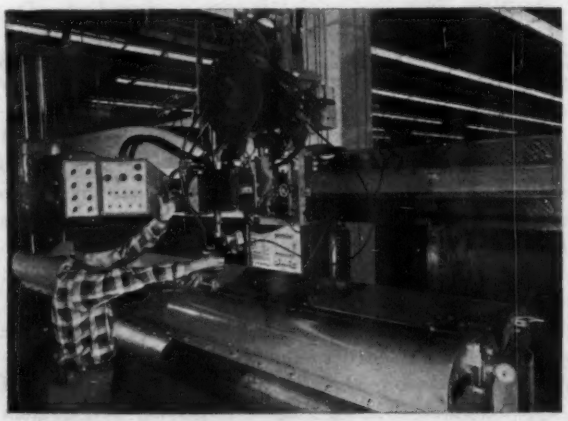
A large number of annunciators are installed across the top of the control console and are used to indicate to the operator malfunctions or dangerous conditions in either the reactor or turbine sections of the plant.

OPERATING EXPERIENCE

THE OPERATING EXPERIENCE on the plant to date has indicated that the equipment provided is adequate and, in general, is very satisfactory. Some of it is superfluous if a plant is designed solely for routine power production. A useful refinement which is now under construction is a graphic display panel showing valve positions and pump conditions. This board will give these indications automatically where suitable limit switches are available, and will have provision for the operator to set up the proper lights where it cannot be done automatically. Consideration should be given in the design of future plants to the installation of sensing elements in such a manner as to facilitate maintenance while the plant is in operation.

Experience at Vallecitos, in general, shows that steam and electrical instrumentation can very nearly follow standard power plant practices, and reactor instrumentation can be much simpler than that proposed for some installations. It need not, in fact, be much more complex than the instrumentation of an equivalent fossil fuel fired plant.

Inert Gas Fusion Welder



Built to the specifications of Boeing Airplane Company, this large Weltronic tungsten inert gas fusion welder is being used to join difficult-to-weld alloys of titanium, stainless steel, aluminum, and magnesium. The machine is fully automatic and capable of a high degree of sequential programming. Arc current, carriage speed, and wire feed are controlled electronically within very close limits by the console, located here behind the radial arm. Either wire or consumable electrodes may be used, and the inert gas may be either helium or argon.

Mechanism for Nontracking Organic Insulations

R. S. NORMAN
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A. A. KESSEL

MOST ORGANIC INSULATIONS are not suitable for high voltage applications in contaminated atmospheres. Under surface arcing conditions, the organic constituents of the insulation decompose to form carbonaceous paths and the apparatus will fail by progressive creepage tracking. This article describes a proposed internal oxidation mechanism to eliminate formation of carbonized tracks upon exposure to surface electrical arcs.

It has been found that hydrated alumina compounded with organic materials in specific quantities is wholly effective in preventing carbonization under all test conditions. The proposed mechanism is as follows:

The high arc temperatures resulting from the electrical discharges rupture the long chain, high molecular weight hydrocarbons. Simultaneously, they act on the hydrated alumina filler, releasing its water of hydration as shown in equation 1.

$$Al_2O_3 \cdot 3H_2O \xrightarrow{\text{Heat}} Al_2O_3 + 3H_2O \qquad (1)$$

In the presence of aluminum oxide and heat, the hydrocarbon fragments react with the water to form hydrogen, carbon monoxide, and volatile hydrocarbons leaving no carbonaceous residue as shown in equation 2.

$$C_nH_m + H_2O \xrightarrow[Al_2O_3]{\text{Heat}} (CH)\uparrow + H_2\uparrow + CO\uparrow \qquad (2)$$

The most conclusive experimental evidence for the oxidation reaction has been obtained by embedding two electrodes in a block sample and testing to dielectric failure. Depending on the susceptibility of the insulation to carbonization, either a carbonized path or a nonconductive gas pocket is observed between the electrodes. The interior of the sample is completely sealed from the oxygen and moisture of the atmosphere so that all reactants for the conversion of the organic components must come from the material itself.

Conventional materials upon exposure to this test no longer hold voltage, and microscopic examinations show a spongy carbonaceous track between the electrodes. However, Butyl rubber samples with high loadings of hydrated alumina produce a gas pocket between the electrodes upon exposure to high voltage. Mass spectrometer analyses of the gases removed from the pocket between the electrodes confirm the internal oxidation reaction.

The creep-track resistance obtained by increasing additions of hydrated alumina in Butyl rubber, epoxide, and polyester resins using the GE Measurements Laboratory dust-fog test is shown in Fig. 1. Tracking resistance on this test could be obtained with 30 to 40% by weight of hydrated alumina. However, it was necessary to load the materials with about 50% hydrated alumina to give optimum protection against formation of carbonaceous deposits on the Measurements Laboratory salt-fog test. On the molded electrode test, it was found that above 60% hydrated alumina no carbonization was noted on any of the Butyl rubber samples and a gas pocket was consistently formed between the electrodes.

Both hydrated and unhydrated materials were evaluated in Butyl rubber. The materials containing larger

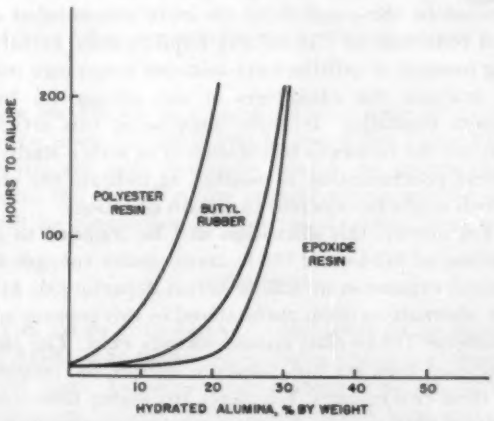

Fig. 1. Per cent hydrated alumina vs time to failure on dust-fog test.

percentages of water appeared to be significantly more creep-track resistant than the unhydrated materials. However, the material critically filled with hydrated alumina was the only insulation to show no signs of carbonization in the salt-fog test and the molded electrode test.

In summary, an internal oxidation mechanism to eliminate the formation of conducting carbon paths in organic insulation exposed to electrical arcs has been described. Mass spectrometer data on analysis of gases formed during electrical arcing provides evidence for this explanation.

For optimum effectiveness in preventing creep-tracking, it has been found that the additive should contain sufficient water of hydration as well as catalyst to prevent the formation of free carbon. Hydrated alumina in specific quantities has been found effective under all test conditions.

Digest of paper 58-211, "Internal Oxidation Mechanism for Non-Tracking Organic Materials," recommended by the AIEE Dielectrics Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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Determination of Optimum Transmission Voltage

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Many utilities, faced with the problems of expansion, have initiated long-range studies to evaluate the possibilities of using extrahigh transmission voltages, such as 345 kv. In this article, 345-kv systems are compared with the more commonly used 138-kv systems on the basis of right-of-way requirements, reliability of operation, and cost.

OVER THE PAST SIX YEARS there has been a rapidly growing interest in the use of extrahigh transmission voltages, particularly 345 kv. Attracted by the possibilities of lower transmission costs and reduction in right-of-way requirements, an increasing number of utilities have initiated long-range studies to evaluate the advantages of this voltage for future system expansion. It is the purpose of this article to outline the factors to be considered in such a study and, where generalization is possible, to indicate the results which might be expected in certain situations.

For clarity, this discussion will be confined to comparison of 345-kv and 138-kv transmission voltages. Continued expansion at 138 kv versus departure to 345 kv are alternatives often encountered in this country where extensive 138-kv class systems already exist. The factors discussed here are not, however, unique to comparison of these two voltages. Whenever any higher transmission voltage than that in present use is contemplated, a very similar analysis is required.

A comparison of two or more transmission voltages to determine the optimum for a purpose at hand involves evaluation of three factors:

1. Comparative right-of-way requirements from the standpoints of land usage and availability.
2. Comparative reliability of operation.
3. Comparative costs.

These evaluations will be in terms of consumer and public relationships as well as dollar expenditures, and on this basis the best voltage is selected.

RIGHT-OF-WAY REQUIREMENTS

THE RIGHT-OF-WAY REQUIREMENTS for 345-kv and 138-kv transmission are a function of the number of circuits needed and the space occupied per circuit in each case. The number of circuits needed is, in turn, inversely proportional to the maximum permissible loading per circuit at each voltage.

There are three factors which limit the maximum permissible loading per circuit at any given transmission voltage. These are (1) thermal capacity of conductors, (2) voltage regulation, and (3) transient stability.

Considering the conductor thermal capacity limitation, the inherent advantage of the higher voltage is indicated by its direct ratio to the lower voltage, or $345 \div 138 = 2.5$. In other words, if thermal capacity of conductors is the dominant limitation, approximately 2½ times as many 138-kv circuits will be required to carry the same kva as a given number of 345-kv circuits. This assumes that conductors of equal current-carrying capacity can be used with either voltage, which appears to be an entirely practical assumption. Large diameter or bundled conductors are required with 345 kv for other reasons than load-carrying ability, but if needed for right-of-way conservation, equivalent conductors may be used with 138 kv.

The voltage regulation limitation is basically a function of impedance. Inasmuch as effective transmission line impedance is inversely proportional to the voltage ratio squared, it follows that $(345 \div 138)^2$ or 6.25 times as many 138-kv circuits will be required to carry the same kva as a given number of 345-kv circuits for the same voltage regulation.

It is difficult to draw a similar comparison for the transient stability limitation, because it is dependent upon many factors extraneous to the question of transmission voltage. Switching and relaying arrangements are often more critical for stability than circuit impedance for transmission distances of 50 miles or less. For longer distances, transient stability is more directly related to impedance than any other function of the transmission voltage. Therefore, it appears sufficiently correct, for this discussion, to state that the ratio of 138-kv to 345-kv circuits approaches 6.25 to 1 for comparable stability. This is only a rough generalization; a detailed study of the application is necessary for an accurate evaluation of transient stability.

Where permission for property use in involved, the landowner is often more concerned with the number of structures to be placed on his land than the right-of-way width required. In such cases, comparative right-of-way requirements for 138 kv and 345 kv may be regarded as the ratio of the number of circuits needed, i.e., between 2.5 and 6.25 to 1. This assumes the same number of circuits per tower at each voltage.

Full text of a conference paper presented at the AIEE Great Lakes District Meeting, East Lansing, Mich., May 5-7, 1958.

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Where outright acquisition of property is involved, the per-circuit difference in right-of-way width becomes significant. It will usually be found that each 345-kv circuit requires approximately twice the right-of-way width occupied by a 138-kv circuit, again assuming an equal number of circuits per tower at each voltage. It, therefore, may be concluded that from a long-range viewpoint 138-kv transmission voltage will require between 1.25 and 3.0 times as much right-of-way area or width as 345 kv to transmit equal kva.

The applicable ratio in each case depends on which factor determines the maximum permissible loading per circuit—thermal capacity, voltage regulation, or transient stability. A study of the proposed application will generally reveal which limitation is dominant. At shorter transmission distances, thermal capacity is likely to be the limiting factor; in which case the ratio 2.5 or 1.25 to 1 applies. At longer distances, voltage regulation or transient stability may be the limiting factors, in which case the ratio 6.25 or 3 to 1 applies. This clearly demonstrates the influence of transmission distance in determining the relative advantage of 345 kv.

In view of the rapid population growth with subsequent home and business construction in many areas of the country, several utilities anticipate that within the next 20 years, maximum utilization of available right of way will be of extreme importance. Also, there are locations where natural obstacles necessitate maximum right-of-way utilization. In such instances, the use of 345-kv transmission voltage will be a means to this end.

RELIABILITY

FROM THE STANDPOINT of reliability, it appears that the use of 138-kv transmission voltage may have appreciable advantages over 345 kv, particularly in the earlier stages of system expansion. Since the use of 138 kv requires some greater number of transmission circuits than 345 kv, it follows that there is inherently greater reliability and operating flexibility. In addition, with 138-kv transmission there will usually be a greater dispersal of step-down transformer capacity within a given service area, resulting in a lesser degree of vulnerability to natural disasters, equipment failures, or operational errors. From a long-range standpoint, however, differences in reliability between 345 kv and 138 kv tend to disappear. In the more advanced stages of system expansion, there will usually be sufficient duplication of 345-kv facilities to give a comparable margin of reliability.

Reliability may also be a factor in determining the comparative short-range right-of-way requirements for 345-kv and 138-kv transmission. For example, suppose that 900 mw of generation is to be transmitted 50 miles to a load center. Assume further that six 138-kv circuits or two 345-kv circuits are the alternatives under consideration. To realize maximum reliability with the 345-kv plan, it may be considered necessary to place the two circuits on separate rights of way. With at least equal reliability, the six 138-kv circuits could be placed on double-circuit towers, thereby requiring only one more right-of-way strip than would the 345-kv plan.

If the capacity to be transmitted doubles at some future time and the alternatives become twelve 138-kv circuits versus four 345-kv circuits, placing the latter on double-circuit towers might be considered to give sufficient reliability. Comparative right of way requirements would then be two strips for 345 kv versus six strips for 138 kv, or a saving of four strips of right of way by using 345 kv. It may be noted that if the 345-kv circuits are not eventually placed on double-circuit towers, the over-all saving in right of way may be quite small by comparison with the equivalent 138-kv plan.

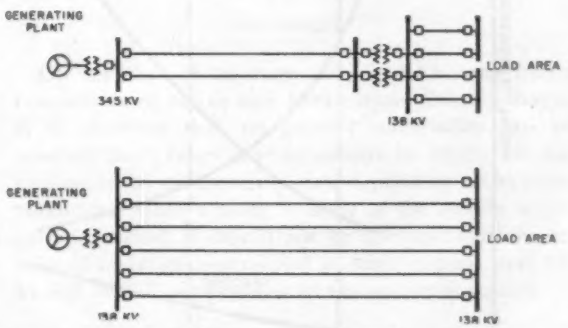

Fig. 1. Comparable 345-kv and 138-kv transmission systems, where an existing 138-kv network in the load area is to be retained.

ECONOMICS

THE THIRD FUNDAMENTAL CONSIDERATION in comparing 345-kv and 138-kv transmission voltages is their relative costs. These costs are composed of (1) carrying charges on investment in transmission lines and substation equipment, (2) capacity and energy charges for I^2R losses, and (3) carrying charges on investment in reactive supply. Operation and maintenance costs may also be included, although they are usually small relative to the other costs.

Before comparing costs, suitable 345-kv and 138-kv transmission plans must be formulated. For example, Fig. 1 indicates typical alternative plans for transmission from a generating plant to a load area where an existing 138-kv transmission network is to be retained. Because of space requirements and the comparatively high investment associated with 345-kv terminal and step-down equipment, it is usually desirable that the number of 345-kv substations in the load area be held to a minimum. As a result, the large blocks of power associated with 345-kv step-down substations cannot be absorbed in the load areas of most present-day systems without 138-kv ties to smaller substations within the area.

In the formulation of alternative plans, consideration must be given to the selection of an optimum

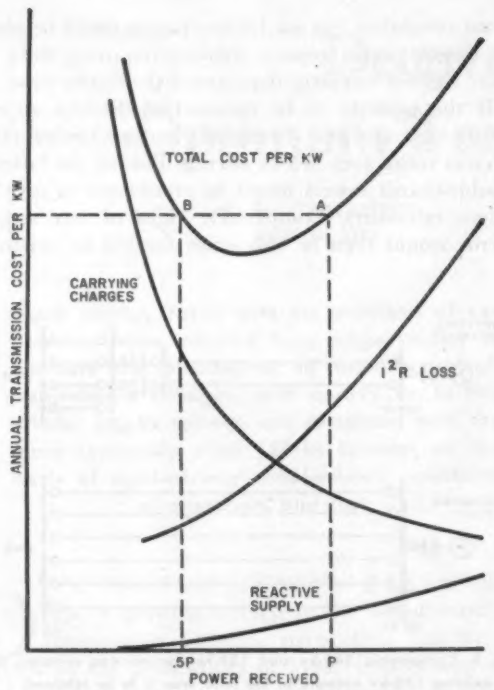

Fig. 2. Relationship of component annual costs for a typical transmission line.

transmission line design for each voltage. Such decisions as bundled-conductor versus single-conductor line design must be analyzed, particularly for 345 kv, but perhaps for 138 kv as well. In preliminary thinking, there may be a tendency to disregard future possibilities for improving or changing conventional 138-kv transmission line design standards. Since comparisons of 345 kv and 138 kv are usually made on a very long-range basis, in many cases up to quadruple present-day loads, it is important that any preconceived design limitations be carefully scrutinized.

In determining the best conductor size for the given transmission application, it will be necessary first to determine the minimum number of lines required to satisfy the established voltage regulation, transient stability, and reliability criteria. These limitations are essentially independent of wire size. With the minimum number of lines established, the optimum size can be selected by a long-term comparison of carrying charges, cost of I^2R losses, and costs of reactive supply for a number of different size conductors which are thermally adequate.

At shorter transmission distances, the voltage regulation and transient stability limitations may become insignificant, in which case thermal capacity and reliability are the major factors determining the number of lines required and the range of suitable wire sizes.

Fig. 2 indicates a typical relationship of component costs for a particular wire size and transmission voltage. A point which may well arise in the course of a study to determine the optimum conductor size is the question of economic loading. Referring again to Fig. 2, it can be seen that as loading on a single line is increased, eventually the point A is reached such that a second line could be added, each line operating at point B, with no increase in annual cost per kilowatt or total annual transmission cost.

Fig. 3 shows a series of curves representing a multiplicity of identical lines. Theoretically, each time the cost curve for n lines intersects the curve for $n + 1$ lines, it would be economical to install the additional line. It can be noted from Fig. 3, however, that with up to three lines in service, the cost at these intersection points is only slightly greater (about 6 per cent usually) than the minimum possible cost. With more than three lines in service, there is practically no difference between the cost at the intersection points and the minimum possible cost. This illustrates the fact that the slope of the composite annual cost curve is very gradually upward once the minimum cost point is reached. It is, therefore, quite doubtful that there would be sufficient potential saving to justify investment in an additional line once the intersection or economic loading range is exceeded, by however small an amount. It would naturally not be prudent to operate a line at a loading far beyond its economic limit, but it appears there should usually be a tendency to operate the line somewhat in excess of its most economic loading. The exact amount can only be determined by study of the specific situation encountered. Summarizing, it appears that although the economic loading concept must be considered in determining the number of lines required to carry a given amount of power, in actual practice it will usually be justifiable to load well beyond the theoretical lowest cost range.

Having selected the most economical 345-kv and 138-kv plans, the remaining step will be to compare the two plans. This comparison will include carrying charges on investment in transmission lines and rights of way, terminal facilities and generator step-up facilities for both plans. In addition, carrying charges on investment in 345-kv step-down facilities and 138-kv ties within the load area must be included in the 345-kv transmission plan, where applicable.

The initial stages of any 345-kv plan will very likely require a very high investment by comparison with an adequate 138-kv plan. Because a 138-kv plan involves smaller increments of transmission capacity, it can be more easily designed to meet the required total capacity at any stage of development, with little excess. It is probable that the first step of any 345-kv plan will involve considerably more transmission capacity than can be immediately utilized, because of the greater capacity per circuit with 345 kv and the need for a certain minimum number of circuits for reliability. Therefore, it is necessary to extend the period of economic study until such time as the capabilities of 345-kv transmission can be fully employed.

The second major item of the cost comparison, capacity and energy charges for I^2R losses, need not be

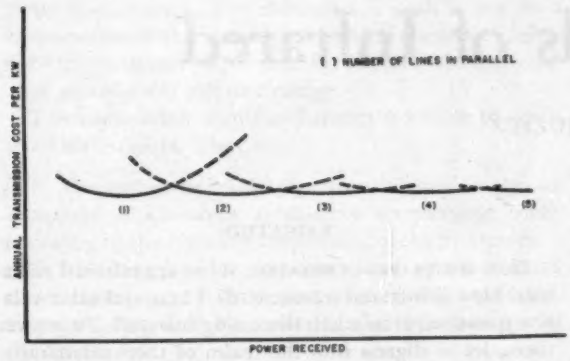

Fig. 3. Typical relationship of annual transmission costs for a number of lines in parallel.

described in detail, inasmuch as these can be determined by quite conventional means.

The third cost item to be considered is the expense of reactive power required for proper voltage control. The vars delivered to the receiving end are often credited at a fixed rate to the plan being studied, based on the cost of an equivalent amount of switched capacitors or synchronous condenser capacity. Before crediting any plan for delivered vars, consideration should be given as to whether these vars are actually required under normal operation. Since voltage regulation becomes more critical with equipment out of service, the amount of vars delivered for such a condition should be evaluated and the worth of the var supply for each plan adjusted accordingly.

SUMMARY

ON THE BASIS of the many factors which enter into a comparison of 345-kv and 138-kv transmission voltages, it is apparent that no general conclusions can be reached. Each factor may be subject to widely varying evaluation by different utilities, depending on existing conditions. Until a study is made of the specific application at hand, it should not be inferred from the results of investigations related to other systems that 345 kv will or will not prove to be the optimum voltage.

Abstracts of Articles from Soviet Technical Publications

The following articles, here abstracted, are among those appearing in *Electric Technology USSR* ("Elektrischestvo"), vol. 2, 1957. Details of the availability of this publication, as well as three other leading Soviet publications, are given in *Electrical Engineering*, June 1958, p. 526.

A New Air-Blast Circuit Breaker for 220 Kv, 7,000 Mva, *T. I. Smirnova.* (No. 6, p. 48.)

An experimental circuit breaker developed at the All-Union Electrical Engineering Institute in Moscow is described. This is an improvement of the 5,000-mva circuit breaker manufactured at present by the Soviet electrical industry. The construction and parameters, as well as the results of tests conducted on the new breaker are outlined.

Turbogenerator Rotor with Direct Cooling of the Winding Conductors, *B. V. Titov, Z. B. Kogan.* (No. 6, pp. 35-38.)

In the course of developing new types of large turbogenerators, the "Elektrosila" Works designed and produced an experimental rotor with direct hydrogen-cooled conductors. The rotor was installed in a 30-mw set in Leningrad in 1956 and was tested in service on load. The new rotor-winding design may be used successfully for hydrogen-cooled turbogenerators of 30- to 150-mw rating. Its weight and dimensions may be 30 to 35% less than those of existing machines.

The Current in the Charge Materials of a Ferrosilicon Furnace, *I. T. Zherdev.* (No. 5, pp. 65-67.)

Despite the difficulties of carrying out experiments on an actual alloying furnace, because of the high temperatures involved, it is possible to demonstrate the existence of a charge current and to approximate the current density in the charge materials under conditions of industrial operation of such furnaces. A description is given of the method and the results of the experimental determination of current density in the charge of a ferrosilicon furnace.

Fundamentals of Infrared

M. S. JUZYCZ

Infrared has emerged in the last decade from the sanctuary of the research laboratory into the domain of practical applied science. It is hoped the basic information presented will stimulate further interest in a field of great potential value.

NATURE is full of intriguing phenomena, and it is up to the human being to discover them, to study them, and ultimately to find useful application for them.

Generally known, almost taken for granted but still mysterious to many, is the ability to see. Human vision, however interesting it is, is only a small part of the whole array of physical phenomena produced by nature.

The investigators of the phenomenon called vision, define it as the ability of the human eye to receive and respond to the signals of very short wavelength and limited to a narrow band in the spectrum. Thus, the first and most widely used narrow band receiver has been established.

Adjacent to the visible light band in the spectrum there are two other spectral regions, usually referred to as ultraviolet and infrared (IR).

It is the subject of this article to discuss and expose the underlying principles governing the behavior of infrared.

INFRARED

THERE ARE TWO THEORIES, based on the undulatory and corpuscular concepts of radiant energy, which try to explain the nature of the infrared. One of them, the wave theory, is familiar to the electronics engineer in spectral regions used for radar, ultrahigh frequency (UHF), and radio.

Radiant energy in the region between visible light and microwaves is defined as infrared. The name was derived from the fact that the spectral region concerned is the extension of visible red. The energy radiated at these frequencies is outside the pass band of the human eye, and therefore, invisible to man. However, the extremely short wavelengths make the infrared behavior very similar to that of light. This is particularly true in the shorter wavelengths region of the infrared spectrum, where the wavelength approaches the magnitude of the wavelength associated with visible light. Because of this, resolution achieved with infrared is very high and far superior to the resolutions commonly obtained at present in the other spectral regions; e.g., microwaves.

A special article recommended for publication by the Production and Application of Light Committee.

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RADIATION

HOW IS INFRARED GENERATED? What are infrared radiators? How is infrared transmitted? These and other relative questions arise when discussing infrared. To answer them, let us digress into the realm of thermodynamics. It is a known fact that heat can be transferred from one body to another by conduction, convection, and radiation, or a combination of them. It should be noted that the radiation at wavelengths longer than visible light and shorter than microwave constitutes the infrared spectrum. Hence, all hot objects will radiate infrared energy. Therefore, in order to generate infrared energy a body, object, or simply a radiator must be brought to a warm state, that is, it must be at a temperature above absolute zero. Conversely, this means that any object radiates infrared energy and, therefore, it is true to say that infrared transmitters are integral parts of any hot body and they are inseparable from it. Quantitatively, two parameters describe infrared radiation. They are, the wavelength and the power, both functions of the absolute temperature of the radiator. The total radiant power varies as the fourth power of absolute temperature. The spectral distribution of radiant power exhibits a peak at certain wavelengths and, in this part of the spectrum, the radiant power varies as the fifth power of absolute temperature. The peak of the radiant power distribution curve is subject to displacement in the spectrum. The wavelength at which it occurs is also a function of the absolute temperature. It varies proportionately to the inverse of the temperature, that is, the peak shifts to shorter wavelength regions at higher temperature. A black body radiator is defined in order to provide a standard radiator although it is only of theoretical importance. It is a body that has absorptivity equal to unity. That is, it absorbs all the energy that strikes it without reflection. Conversely, if used as a radiator it radiates maximum energy at given temperature. A grey body in turn is any body whose absorptivity is less than unity and has the same value at all wavelengths. The rate at which a grey body emits radiant energy depends upon the temperature of the body and on its emissivity which is a function of its surface. The emissivity of a body is defined as the ratio of the grey body radiation to that of a black body and is always less than unity.

TRANSMISSION AND ATTENUATION

IF THERE WERE NO ATMOSPHERE in the transmission path of the infrared energy, that is, if the infrared transmission were occurring in a vacuum, the energy at any distance from the IR source will be proportional to the inverse of the square of that distance. This ideal state

is far from reality. The transmission path is not in a vacuum but in the atmosphere, which attenuates infrared energy. Water vapor and carbon dioxide are principle absorbers of infrared energy.

The attenuation of infrared energy is known to result from three causes. They are:

1. Absorption by molecular constituents of the atmosphere which occur at discrete wavelengths corresponding to the resonant frequencies of the molecules.
2. Scattering by haze, fog, and cloud particles, many of which are large with respect to the wavelength and, therefore, attenuate by scattering the radiation out of the beam.
3. Scattering by air molecules.

Because of these properties; i.e., scattering and absorption, the attenuation is not uniform throughout the spectrum; in fact, the atmosphere has a number of free transmission bands located in different parts of the spectrum and referred to as "transmission windows." The air density and the composition of the atmosphere varies with altitude. In higher regions, the attenuation decreases markedly thus enabling transmission and detection over large distances. Until now, only one transmission medium—the atmosphere—was considered. In a sense, it is the major medium because it constitutes the only known long-distance transmission path. However, other transmission media exist; e.g., auxiliary equipment such as collective optics as used in the infrared equipment. The transmission of the infrared energy through such equipment is governed by the physical properties of the materials used. These materials may vary in the degree of attenuation and feature different spectral distribution characteristics. In order to assess and predict infrared transmission in a given environment under given conditions, it is necessary to work out an integrated transmission characteristic for the complete infrared system.

RECEPTION

Earlier sections dealt with the generation of infrared energy, with its radiation and transmission problems. In this section, it is intended to discuss problems related to detection.

The ideal detector should have the following properties: (1) high sensitivity over the entire infrared spectrum; (2) low noise figure; (3) fast response time.

Most of today's infrared systems are passive systems. A passive system utilizes infrared radiation emitted by an object. The system usually has no manufactured transmitter, and has only an infrared receiver. Such a system is possible because of the fact that any object at a temperature above absolute zero radiates infrared. Therefore, all objects in known environmental conditions will radiate infrared.

The importance of the infrared detector becomes evident if it is realized that usually not much control can be exercised over the prevailing conditions at the transmission end. Mostly, they are governed by some other criteria be it thermal, structural, or a combination of them. As a matter of fact, this is one limiting factor of the passive infrared system.

However, if use is made of the radiation properties of the body, the detector is a powerful instrument at the designer's disposal, which offers the possibility of technically optimizing the system.

There are two basic types of infrared detectors, one working on a thermal principle, the other using a photoconductive phenomenon. In the first group, there are two types known: They are, bolometers and thermocouples. The operation of bolometers can be described as: the IR energy incident on the platinum foil of a bolometer warms it up and produces a change in the resistance of the platinum foil. The change of resistance is the measure of IR power at the point of reception. Thermocouples respond also to the heating effect of IR radiation. Two very fine wires of different materials are spot welded and attached to a thin foil which acts as a radiation receiver. As a result of heating this area, a small internal d-c voltage develops in the thermocouple and the current change is the measure of IR radiation. This is a low impedance device, actual impedance values being in the order of 5 to 10 ohms.

Most common thermocouple pairs are of bismuth silver and copper constantan. The detectors in the thermal group respond to infrared of any wavelength that contributes to the warming up of the sensitive elements. As such, they are integrating instruments responding over a wide band of the infrared spectrum (up to 15 microns). The sensitivity of this type of detector is inferior to the sensitivity of a photoconductive cell.

The time constant of the detector is a function of the heat capacity and the rate of energy loss. For all thermal detectors it is long, in the order of several microseconds, and this must be remembered if measurements of fast changing infrared signals are made.

The second major group of infrared detectors consists of photoconductive cells. The basic explanation of the operation of photoconductive cells is found in Planck's quantum theory. A photoconductive cell exposed to infrared radiation changes its state by absorbing photons from the incident infrared energy which in turn changes its resistance. If there is no infrared illumination the cell resistance is high; however, it decreases when the cell is exposed to infrared radiation. As a result of the change of resistance, the applied voltage drops. The change of voltage is the measure of the infrared energy to which the cell was exposed.

There are several important differences between thermal and photoconductive infrared detectors. The time constant is one of them. By virtue of the photoelectric phenomenon, the time constant of photoconductive cells is very short. It does not require the warm-up time necessary for thermal detectors. The sensitivity of the photoconductive cell is also high compared to the thermal type detector; however, additional cooling is required to optimize sensitivity conditions. Another major difference is the spectral band to which the cell responds. It is limited in the longer wavelength region of the infrared spectrum.

There are several materials used for photoconductive cells. Lead sulphide is one of the earliest. It was developed to its present state of perfection during World War II. It has a high sensitivity, 5×10^{-11} watts, particularly if cooled, and cuts off at approximately 4.5 microns. Another cell uses lead telluride. It is a new material which has a sensitivity of 10^{-11} watts and cuts off at approximately 6.2 microns.

The advancement of research and development of semiconductors resulted in better materials such as lead selenide, indium antimonide, specially treated germanium and others, all of which require very low temperature to achieve higher sensitivity figures. Further work is being done and hopes are high for more and better type detectors.

Still another type of detector is the photosensitive emulsion responding to infrared radiation. Films using emulsion have numerous applications in infrared photography.

ACCESSORY EQUIPMENT

BECAUSE OF INFRARED CHARACTERISTICS which resemble visible light, certain parts of the detection system can be built with components known in optics.

Mirrors, lenses, and prisms are used for collection, deflection, and focusing of incident infrared energy.

Class and quartz have poor transmission characteristics in the longer wavelength infrared regions. Therefore, other materials are used. Good examples are thallium halides, which have a range of transmission between 2.5 to 35 microns and are essentially nonhydroscopic. Both are highly desired properties in infrared equipment design.

There are numerous applications of infrared. The principle industrial use of infrared is in radiation heating, drying, and baking of such materials as paints, enamels, varnishes, glues, and printers ink. Closely associated with this group is the usefulness of infrared in temperature measurements. Heat therapy and application of infrared microscopy in the field of ophthalmology are typical uses of infrared in medical science. Spectroscopy assumes an increasingly important role in the identification of compounds, especially hydrocarbons. Its importance is not limited to the laboratory as it has extensive uses in process control. The existence of infrared energy emitted from warm objects opens up a vast field in infrared utilization. In this group infrared photography is a typical example since infrared attenuation by clouds and haze is less than that for visible light. Hence, photography of scenes and objects completely invisible to the human eye is made possible. Another typical example is an infrared viewer enabling one to see at night. Its primary use is for night driving. Although the list is far from complete, it is representative of the present day applications of infrared.

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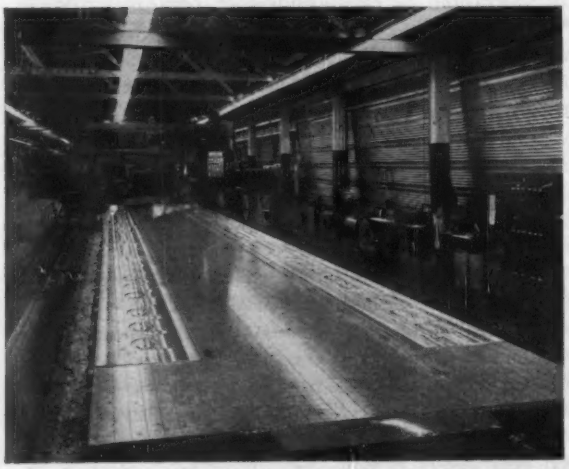
Sculptured Wing Skin



This 12-foot by 80-foot Kearney & Trecker skin mill is shown producing simultaneously two sculptured wing skin panels for the Boeing *B-52G* Stratofortress. All intricate motions of this giant skin mill are controlled by information on magnetic tape. These two integrally stiffened wing panels are among the longest aircraft parts ever to be machined to extremely close tolerances.

An advanced model of Boeing's line of heavy jet bombers, the *B-52G* will serve as a launching platform for the *GAM 77* "Hound Dog" supersonic guided airborne missile, recently announced by the U. S. Air Force, and will fly farther, strike harder, and defend itself better than any other aircraft now flying.

This huge skin mill is only one of several such machines at Boeing's Seattle, Kans., and Wichita, Kans. plants. The Wichita plant alone is using eight electronically controlled machines—three skin mills, three profile mills, and two automatic riveters—in *B-52G* Stratofortress production; this represents the largest concentration of such equipment in the world. Company officials point out that the extensive use of these "machines of tomorrow" allow production of the United States' newest strategic air weapon at significantly reduced cost to taxpayers.

Six-Channel Multiplex for Submarine Cable Telegraphy

H. F. WILDER
MEMBER AIEE

THE RICHLY CULTIVATED CARIBBEAN area has imposed ever-increasing demands upon communication facilities to North America. To serve this market place and crossroads of transportation, the Western Union Telegraph Company operates three submarine telegraph cables between Havana, Cuba, and Key West, Fla., an average distance of 101 nautical miles. Originally operated duplex in a differential polar relay arrangement, each cable was capable of sustaining a 3-channel time division multiplex at a signaling speed of 50 cycles per second.

As a first step in achieving higher signaling speeds, the cables were equipped in 1955 with signal-shaping vacuum tube amplifiers. Subsequent transmission trials showed the feasibility of signaling at 100 cycles per second. Based on these test results, design of 6-channel multiplex equipment was initiated.

The sending terminal is shown in Fig. 1. Teleprinter line signals at the rate of 368 operations per minute are received on individual start–stop distributors. Each distributor delivers the regenerated intelligence impulses to alternative capacitor storing banks of a channel repeater used to couple each teleprinter line to a multiplex channel without the use of tape reperforation. Whenever the multiplex, rotating at 375 rpm, "catches up" with the teleprinter signals an auto-stop circuit prevents the delivery of stored information to the cable and transmits a single blank to restore the required time lag.

The large 6-channel distributor is equipped with a faceplate possessing all the segmented rings necessary to both sending and receiving functions. A special ring provides 22 millisecond timing intervals when either translating the multiplex signals to teleprinter signals at a receiving terminal or when monitoring the transmitted signals at a sending terminal.

Because of highly inductive antinoise sets in the apexes of the Havana cables, a sending vacuum-tube amplifier is interposed between the sending segments and the cable to prevent segment gap flashover. This amplifier impresses only the high-frequency components of the signal upon the duplex apex; the d-c component and intermediate frequencies are still supplied from the segments but through a resistive-capacitive network.

To provide a reliable means for monitoring the transmitted signals, the actual current entering the cable bridge apex is caused to drive a high-speed monitor relay. The multichannel multiplex signal output of this relay is then returned to a vacuum tube translator that in conjunction with the teleprinter timing ring restores the start and stop pulses of a given channel to permit monitoring on a 60 wpm teleprinter.

The receiving terminal is similar in construction and appearance. The output of the signal shaping amplifier drives a line and a corrector relay. The line relay and a selector relay in conjunction with 30 scanning segments regenerate the signals and deliver the impulses to storing capacitors. Each group of five capacitors is then discharged by respective segments on the teleprinter timing ring through a transformer having seven primary windings. Of the seven timing segments for each channel, the first segment discharges a positively charged capacitor through the number one winding of the transformer to prefix the start impulse to the teleprinter character being developed. Similarly a seventh but negatively charged capacitor is provided to produce the stop impulse. The voltage transients induced in the transformer secondary drive a vacuum tube bistable amplifier that, in turn, positions a relay controlling the outgoing teleprinter line.

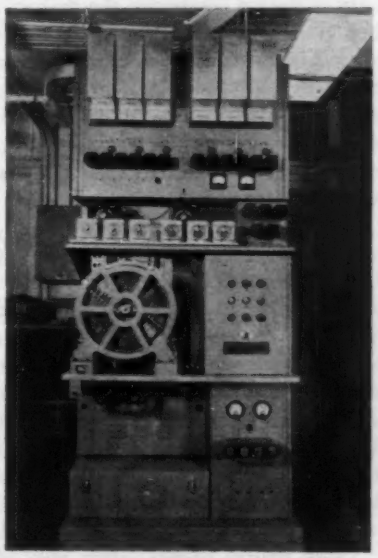


Fig. 1. Sending terminal equipment.

The 6-channel equipment was placed in service in April 1957 and immediately provided three additional duplex teleprinter channels to Havana. A second set of 6-channel equipment will be installed on another Havana cable early in 1958.

Digest of paper 58-44, "An Improved Six-Channel Time Division Multiplex for Submarine Cable Telegraphy," recommended by the AIEE Telegraph Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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Digital Computers for Distribution Systems

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Exactly what is the nature of the "computing revolution" that is now under way and, specifically, what is the future for computers in distribution engineering? These are some of the provocative questions discussed in an attempt to assay the significance of digital computers for power distribution.

A "REVOLUTION" according to Webster's dictionary, is "a great change in the way of doing things," and this has certainly been the case in the field of digital computers. Consider the most elementary form of digital computer, the desk calculator. With the desk calculator, the "program" for problem solution is carried in the operator's head, and the speed of calculation depends not only on the operator's ability to punch the correct keys quickly, but also on his ability to write down quickly (i.e., memorize for future reference and gain access to) various numbers at all stages of computation.

From a brief consideration of desk calculator use, it can be seen that the three contributing functions in digital computation are: (1) a list of instructions, (2) the means to carry out those instructions, and (3) a "memory" to store intermediate and final results. The ways in which all three of these functions have been improved at a revolutionary rate within the past decade is a subject in itself. But for the purposes of rough illustration, consider a distribution engineering problem which takes 100 hours to solve with the use of a desk calculator. Digital computer progress in the calculating time for such a problem is shown in Table I.

These figures convey some idea of the increase of computer "power" in recent years. The pace is indeed revolutionary. However, Table I deals with calculating time. The preparations involved in readying a digital computer (including the engineer–desk calculator combination) to perform its computations are not included in these figures, but will be discussed later.

THE COMPUTER AND THE ENGINEER

IT IS OFTEN SAID, nowadays, that one of the principal advantages of a high-speed computer is that its use frees the engineer from tedious, repetitious calculations, and permits him to devote more of his time to true engineering. This evaluation indeed can be true, but it conveys neither the complete picture of the benefits to be derived from computers, nor the picture with regard to drawbacks and possible pitfalls.

A computer can carry out arithmetic and algebraic computations thousands of times a second, but another important advantage of its application is the requirement for clear, precise thinking in the instructions given it. Instructions containing any slip in logic, any contradiction in premises or assumptions, or any unbalance between two sides of an equal sign cannot be carried out. Should a program contain such slips, a "tilt light" jars the engineer or computer programmer into the effort required to correct the mistakes which prevent problem solution. Consequently, in engineering applications, the computer not only performs many calculations quickly, but also serves as a constant monitor of engineering thought consistency, accuracy, and in some cases, quality. More of the engineer's time is spent in evaluating assumptions, examining logic, analyzing the validity of basic formulas, and choosing suitable ranges of values for variables, while the computer takes specific tabulated numbers, substitutes them into generalized relationships, and comes up with specific answers.

However, whereas the old-style desk calculator is synonymous with tedium to many engineers, the digital computer gives birth to a time consumer just as voracious but of completely different form, commonly called the "bug." This picturesque term applies to errors in programming which halt the computer, or cause it to get on the wrong track.

DIVISION OF LABOR

AS AN ENGINEER SHOULD SUSPECT, with a computer you do not get something for nothing. Translation of a problem solution into language the computer can digest requires a high degree of skill and training. Also, it should be recognized that in some cases an equal, or even greater, amount of time must be spent in computer programming than would be required for a manual (desk calculator) solution. The "payoff" in computer use, of course, comes when the same calculations must be repeated often, changing only the values of the number to be operated on. The subject of programming and its effect on usefulness of computers in engineering problems deserves careful scrutiny.

The process of solving a problem by digital computer involves a "division-of-labor" approach. There are three distinct steps in the process:

Step 1. Problem formulation and engineering analysis leading to a method of solution.
Step 2. Programming or organization of the instructions given to the computer.

A special article recommended for publication by the Distribution Subcommittee of the Transmission and Distribution Committee.

D. N. Reps is with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

Step 3. Coding of the program instructions into a symbolic or numerical language which the computer actually can operate on.

In some cases, all three steps can be done by one individual. Such an individual generally would have to be an engineer, so that Step 1 could be accomplished. A "one-man digital-computation assembly line" would more likely be an engineer who has learned the rudiments of computer programming and coding, rather than a mathematician who has acquired a background of theory and practice in the particular engineering field of the problem. However, if an engineer spends more of his time in programming, coding, and "debugging" than would be required to obtain the solution manually, nothing will be gained.

But tedious longhand computations are really not comparable to computer programming insofar as time well-spent is concerned. Computer programming is intellectually stimulating. A knowledge of programming is a versatile, flexible tool applicable to many different problems. Also, some programming experience helps the engineer to prepare the material required for programming and coding better.

The effect of programming, coding, and debugging time on the efficiency of a digital computer as compared with a desk calculator is illustrated by Fig. 1. The various time intervals depicted in this figure represent reasonable estimates relating to the typical distribution engineering problem mentioned previously, which requires 100 hours of computations with a desk calculator. Although one, two, and even three repetitions of the same set of calculations can be performed in less time by desk calculator, as the number of times the calculation is repeated beyond the break-even point increases, the automatic digital computer becomes increasingly more desirable.

The high cost and great demands for time on high-powered computers necessitate maximum efficiency in their use. One of the aids in improving efficiency is the relegating of engineering, programming, and coding to different people specialized in each job, but with a working knowledge of each other's problems so that good co-ordination of effort is realized. To further this aim, computer manufacturers and users are conducting classes and schools at an ever-increasing frequency.

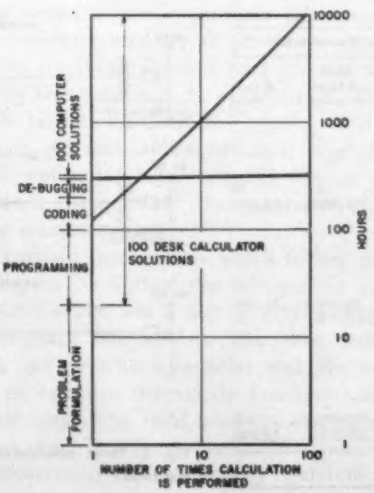


Fig. 1. Comparison of time required to obtain solutions to a problem with desk calculator and electronic digital computer.

THE THREE TYPES OF ENGINEERING CALCULATIONS

IN HIS ARTICLE entitled "The Computing Revolution,"[1] Dr. E. L. Harder segregates the many different engineering calculations into three basic categories: (1) performance calculations, (2) design calculations, and (3) optimization.

An engineer who has never used a digital computer will recognize, from his intuition alone, and certainly from his experience, that the problem becomes more difficult and involved as calculations progress from performance to design, and then to optimization. Generally, optimization means that the engineer is not satisfied with a design that works. He wants, for example, the lowest cost design that meets performance requirements.

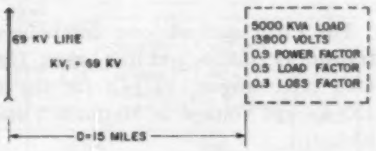


Fig. 2. Distribution system problem 5,000-kva load must be supplied most efficiently and economically.

COMPUTER APPLICATIONS TO DISTRIBUTION

THE NUMBER and variety of problems in distribution engineering are very great. Many of these problems lend themselves to digital-computer techniques. Perhaps the easiest way of illustrating the ways in which digital computers can be applied in distribution is by means of an example. The following example is specifically designed for this purpose. After presentation of this example, it will be easier to use generalities in discussion.

Statement of Problem. Using Fig. 2 let us consider that the problem is as follows:

Problem: A load of 5,000-kva peak demand must be served at 13,800 volts, and is located at a distance of 15 miles from a 69-kv line. Power is to be delivered to this load by tapping the 69-kv line which will operate at constant voltage at the tap point. The maximum permissible voltage drop to the 13.8-kv bus is 5%. Determine the most economical method of supplying this load.

General Statement of Solution. Engineering experience applied to the initial study of this problem indicates that there are three methods of serving this load. These three methods are shown in Fig. 3. They are as follows:

Method 1. A 69-kv line tap is carried the 15 miles distance to the load where a step-down transformer rated 5,000 kva, 69/13.8 kv, is located.

Table I. Digital Computer Progress in the Solution Time for a Certain Problem

Method of Solution	Calculating Time (hours)	Era of Application
Desk Calculator	100	Up to 1950
IBM *604*	1	1950-1953
IBM *650*	0.1	1953-1956
IBM *704*	0.01	1956-

Method 2. A 5,000-kva, 69/13.8-kv transformer is located directly at the 69-kv tap, and a 15-mile, 13.8-kv line is carried from the point of transformation to the load.

Method 3. An intermediate voltage, say 34.5 kv, is used to carry power from the 69-kv line to the load, with a 5,000-kva, 69/34.5-kv transformer at one end, and a 5,000-kva, 34.5/13.8-kv transformer at the other end.

For each method, cost components should include transformers, line, and line losses. The cost of automatic load tap-changing (LTC) for the transformers rated 13.8-kv low voltage in Methods 2 and 3 should also be included.

Writing the Equations. The next step is writing down the equations required for the calculations. As in all other analyses where equations are written, reference should be made to the circuit diagrams, in this case, Fig. 3:

$$I = \frac{\text{kva}}{\sqrt{3}\text{kv}} = \frac{5{,}000}{\sqrt{3}\text{kv}} \tag{1}$$

$$\text{Per cent voltage drop} = \%\ X_{T1} + \%\ X_{\text{Line}} + \%\ X_{T2} \tag{2}$$
(per cent reactances on a 5,000 kva base)

$$\text{Kw power loss} = I^2 R_{\text{Line}} \times 3 \times 10^{-3} \tag{3}$$

$$\text{Capitalized cost of losses} = \frac{(\text{Kw power loss})\ (\text{Loss factor})\ (8{,}760)\ (\text{Dollars/kw-hr})}{\text{Fixed charge rate}}$$

$$= \frac{(\text{Kw power loss})\ (0.3)\ (8{,}760)\ (0.01)}{0.15} = 175.2\ (\text{Kw power loss}) \tag{4}$$

$$\text{Total cost} = \text{Cost of } T_1 + \text{Cost of line} + \text{Cost of } T_2 + \text{Cost of LTC} + \text{Capitalized cost of losses} \tag{5}$$

The distribution engineer will immediately recognize the over-simplifications in the foregoing equations which, like this problem, are designed for the purposes of illustrating digital-computer application.

Tabulation of Data. Up to this point, the steps are the same whether the problem is to be solved using a slide rule (or desk calculator), or a digital computer. Similarly, the next step has to be carried out in very much the same manner for either method of computation. This step is the tabulation of the various numerical values to be used for the variables in equations 1 to 5. However, to facilitate digital-computer application the numerical values are designated, and tabulated as shown in Table II, in a fashion the purpose of which will become clear later.

The Flow Diagram. Now the computation methods using slide rule or desk calculator, and digital computer, take different paths. For "manual" computations, a tabular form for results of individual computations and component and total costs may be set up, and the job of grinding out the various computations begins. For the digital computer approach, the next step is the development of a flow diagram. Such a diagram is shown in Fig. 4.

The flow diagram begins by showing the data (i.e., the numerical values for variables and constants) which must be stored inside the memory of the computer. Then various steps of data selection, calculations, testing of results, and printing of answers are shown in schematic form, in the order in which the steps are to be performed by the computer. Note that Method 1, 2, or 3 is designated by the numerical value of M, and that each of the four cases (i.e., different line conductor sizes listed in Table II) within each method is designated by $C = 1, 2, 3$, or 4.

Note also in Fig. 4 flow diagram that the three types

Table II. Tabulation of Numerical Values

	Case No.	Xfmr No.	For 15 Miles of Line: Conductor Size	%R	%X	$ Cost	For Transformers: %X_T	Xfmr $ Cost	LTC $ Cost
Method 1 M = 1	1		See %R and %X	0.110	1.10	110,000			
	2			0.120	1.20	120,000			
	3			0.130	1.30	130,000			
	4			0.140	1.40	140,000			
		T1					0.	0.	0.
		T2					6.0	30,000	12,000.
Method 2 M = 2	1		See %R and %X	0.210	2.10	210,000			
	2			0.220	2.20	220,000			
	3			0.230	2.30	230,000			
	4			0.240	2.40	240,000			
		T3					6.0	30,000	12,000.
		T4					0.	0.	0.
Method 3 M = 3	1		See %R and %X	0.310	3.10	310,000			
	2			0.320	3.20	320,000			
	3			0.330	3.30	330,000			
	4			0.340	3.40	340,000			
		T5					6.0	30,000	0.
		T6					5.0	25,000	12,000.

Constants 5,000.; 1.732; 3; 0.001; 8,760.; 0.01; 0.15; 175.2

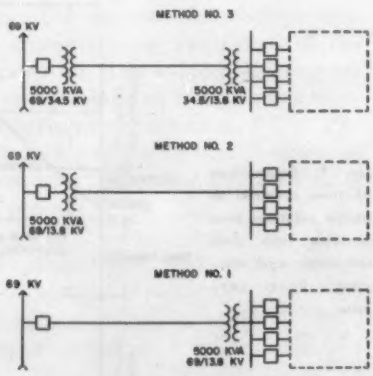


Fig. 3. Three alternative methods for supplying load.

of engineering calculation, namely performance, design, and optimization, are all included in this problem.

Coding. The coder works from the flow diagram and tabulation of numerical values. To illustrate the coding procedure, a coding method similar to the FORTRAN IBM Mathematical Formula Translating system for the IBM-*704* will be employed, modified for the sake of illustration, but nevertheless embodying its basic principles.

The FORTRAN is an automatic coding system for the *704* electronic data processing machine. It is a system in which problem-solution coding instructions can be written in language readily understood by engineers not previously trained in computer programming. The computer takes such "source program" instructions from punched cards and translates them into a new "object program" which is the output of the FORTRAN computations, so to speak. This object program output is also punched on cards automatically by the computer. The object program cards are then reinserted into the *704* computer, and the numerical answers to the problem emerge either punched on cards, printed on paper, or read onto tape depending on the output instructions. Although the engineer can usually understand the source program in FORTRAN language, the object program, were it printed from the punched card, would be unintelligible to him. But inasmuch as the object program is only an intermediate step in the process, this should not present any problems to the engineer.

Table III shows the instructions as they would actually be written by the coder. The instructions resemble FORTRAN, but are simplified or changed to eliminate the need for explaining minor details here. Each line of numbers and symbols are the actual numbers and symbols which would be punched on a single IBM card by a key-punch operator. In all, the complete coded program is punched on 25 cards. Cards 1 to 6 contain the numerical values of variables, written in the order in which they will be called for by the later instructions. Card 7 is a "dimension" statement, necessary in order to assign a proper number of storage locations in the computer memory to prevent overlap or superposition of numbers. Cards 1 to 7 are not instructions, but only information to be operated on. The actual instructions begin with Card 8.

All cards of both the data and instruction type are first read into the computer before control returns to the first instruction, now inside the computer, for commencement of computations.

Cards 8 to 25 contain instructions which follow the flow diagram (Fig. 4). Note that the instructions are readily understandable and are a sort of combination of the English language and algebra. They can easily be interpreted by anyone who is familiar with the engineering problem but not necessarily familiar with computer programming. The IBM FORTRAN system of instruction coding resembles these instructions insofar as principles are concerned, but not exactly in detail.

Time Required for Example Problem. The example problem is a simple one, designed to illustrate computer application, so that the relative amounts of time required for problem formulation, engineering analysis, programming, coding, debugging, and computer calculating may not be typical. Nevertheless, Table IV is included to convey some idea of the order of magnitude of these respective man-, and machine-hour requirements.

COMPUTERS PUT MORE PEOPLE TO WORK

A MODERN HIGH-POWERED electronic digital computer is essentially one tool in the production line of engineering work. As in all work involving organized effort, the capabilities of the components must match.

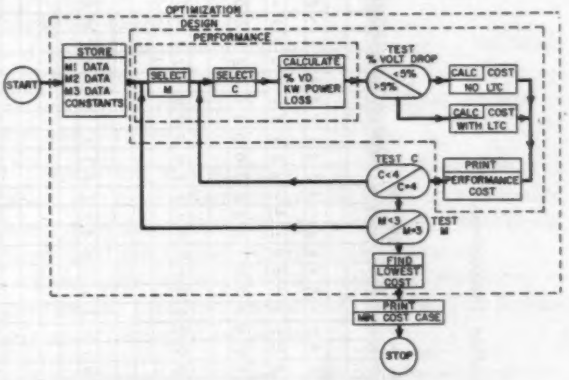


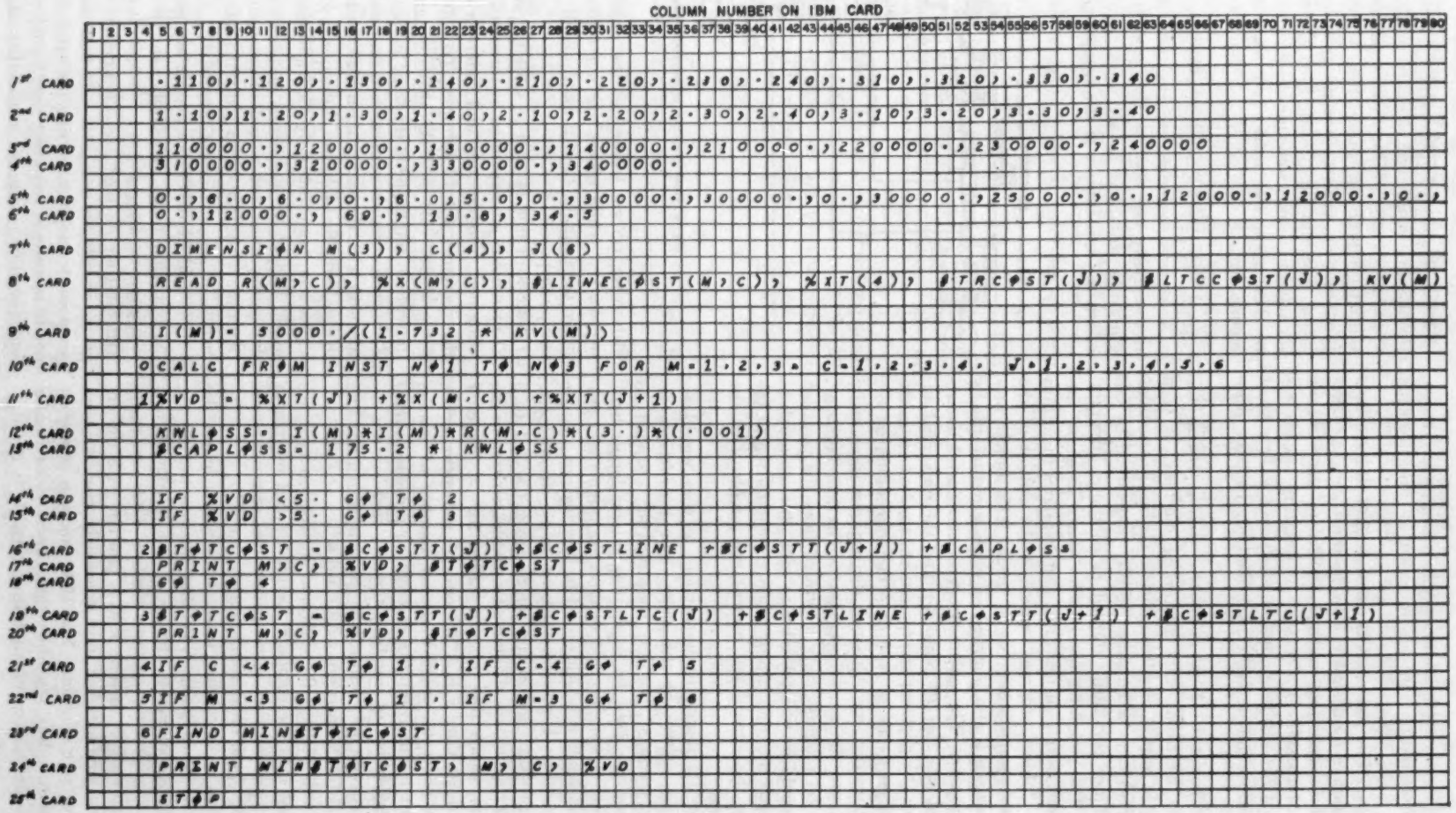
Fig. 4. Flow diagram of problem solution.

Otherwise, certain sections of the production line are overworked while others are not fully utilized. Computer use requires careful matching of manpower and computer power.

Note in Table IV that to solve the sample problem, 21 man-hours are expended by three different specialists —engineer, programmer, and coder—in order to utilize the computer for 10 minutes. To solve the problem using a slide rule or desk calculator, an engineer—one individual—might spend the same amount of man-hours. Thus, three people replace one, and the three in combination with the computer utilize the same man-hours to obtain the first solution. Subsequent solutions of such a problem, for which only the input data are changed, would require no additional programming, coding, or debugging time, and would increase computer utilization time with little or no additional man-hour requirements.

It is evident that more people are required to keep the computer busy. To obtain some idea of personnel requirements, assume that a computer is to be kept busy half the time on repetitive calculations for which programs already are available, and half the time on new program development. Using the ratio of 21 man-hours per 10 minutes of computer time for development work, and assuming computer availability of 16 hours per

Table III. Coding Instructions.



week for such work, the number of man-hours per week required for 16 hours of computer use is:

$$\frac{(21)\ (60)}{10}(16) = 2{,}016 \text{ man-hours per week}$$

This represents the efforts of approximately 50 people.

The examples cited, because of their simplicity, hide what many consider to be the major advantage of digital computer use—the availability of a means for solving problems hitherto thought too difficult or time consuming. Such problems are often concerned with optimization in fields where previously only satisfactory designs could be obtained economically.

In permitting very rapid numerical computations, the digital computer serves as a hub of organized effort. The increases in productivity heretofore applied in industry with great success on the production line have reached the field of engineering work. Unless advantage is taken of the increased productivity through increased levels of output, the high-capacity computing machine is operated at very costly and inefficient low levels of production.

However, quantity of output, in this case in the form of problem solutions, is not the only measure of computer performance. Quality of output; e.g., optimization rather than design, must be sought. Increased scale of operations (i.e., more people, bigger machines, and bigger problems to solve) are an inevitable outgrowth of computer use. This is another example of how technological advances put more people to work.

COMPUTER APPLICATIONS NOW AND TOMORROW

THE EXAMPLE OUTLINED describes the various steps in computer application to a specific problem in distribution. More practical applications are generally similar in principles, but more complicated in procedure and details. One such application, now completed, is the determination of the most economical means of regulating the voltage on distribution primary-feeder circuits.

A program[3,4,5] is now available for the *IBM-704* computer which will take the actual load and line data for any specific primary feeder circuit of any voltage, and the stipulated voltage regulation requirements, and compute the most economical combination of voltage regulators, fixed and switched shunt capacitors to provide the required voltage regulation. This program was worked out through the co-ordinated efforts of the Westinghouse distribution engineering and analytical departments. The comparable long-hand solution of such a problem for a typical primary feeder circuit would take approximately four man-weeks of computations by an engineer employing a desk calculator. The computer program requires about one hour for the punching of the data onto the cards, and about one minute of computer calculating time. The results, printed out by the computer, include the following information:

1. Voltage profiles for all workable combinations of regulators, fixed and switched capacitors.

Table IV. Time required to obtain answer to sample problem, using *IBM 704* computer and FORTRAN programming system.

Operation	Time Required	By Whom
Statement of problem and method of solution	2 hours	Engineer
Writing the equations	1 hour	Engineer
Tabulation of data	3 hours	Engineer
Develop flow diagrams	3 hours	Engineer and Programmer
Coding in FORTRAN	4 hours	Coder and Programmer
Translate FORTRAN program into machine language program	3–3 minute runs	*704*
Debugging program between the 3 runs above	2–4 hours	Programmer and Coder
Complete run to compute and print out answers	1 minute	*704*

2. Ratings and locations on the line for regulators, fixed and switched capacitors.

3. Costs of equipment, and total system costs for each workable design.

4. System capability requirements to serve the load, which as seen by the system, would vary depending on the amount of capacitors employed, and the amount of I^2R and I^2X losses incurred.

Considering that all this information is available in about one hour's data preparation time, plus one minute's computing time for any primary feeder circuit, one would not hesitate to call this a revolution.

The future for application of digital computers to distribution problems indeed looks bright. The following areas offer especial promise:

1. Optimization of power and distribution transformer design to best serve today's and tomorrow's loads.

2. Determination of most economical over-all distribution-system voltages and patterns.

3. Statistical analysis of existing and future loads for system planning purposes.

4. Replacement of some a-c calculating board and d-c calculating board applications such as secondary network studies, by digital computer programs.

5. System reliability and service continuity improvement by means of very rapid consideration and analysis of possible operating difficulties.

The list of possible digital computer applications to distribution problems is indeed impressive, and challenging. Any young man about to graduate from college and enter the electrical engineering profession should be enthused at such opportunities for creative and important work.

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The Philosophy of Engineering Reliability

M. L. MILLER
MEMBER AIEE

This second half of a two-part article expands upon the uses of the present definitions and concepts and attempts to show how reliability of parts influences system reliability. The importance of life testing is discussed briefly along with some comments on system design.

Part II

IN PART I of this article, the mechanisms by which engineering reliability is created not in the product by the designers, but in the minds of the people who buy and use the product was discussed. This is of interest because not only does it influence the way the designer must design his product, but also it helps provide the ultimate decision as to whether he will stay in business.

The first part indicated that the concept of reliability is closely related to predictability, assessability, and probability; and that both subjective and measured reliability must be considered. It also provided a definition of reliability. The most simple statement of which is: "A more reliable device is one that is more apt to complete its assigned mission without failure."

Our attention now will be turned toward using the definition of reliability for devising methods of measurement.

METHODS OF EVALUATION

AS MENTIONED IN PART I, only statistical methods are considered a suitable nonsubjective means for evaluating future performance and, therefore, of measuring reliability. For this reason, the following information is helpful in determining the reliability of a device or system. If a great deal is known about the parent family, it may be possible to derive the shape of the reliability curve from experience (a subjective evaluation) plus only a limited amount of statistical data.

For example, if it is known that there is no wear-out phenomena present in the portion of the life curve of interest, it can frequently be assumed to be an exponential, with a constant failure rate. This sometimes makes it possible to provide a rather simple means of finding numerical life data.

A special article recommended for publication by the AIEE Research Committee.

M. L. Miller is with the General Electric Company, Fort Wayne, Ind.

Experience and Life Testing. To see how experience can be used to simplify testing, let us take for example a small electric motor such as a fan motor. Past experience might indicate that a few per cent of these motors fail more or less at random throughout their life from a number of miscellaneous causes such as insulation failure, metal fatigue, poor solder joints, defective castings, etc. This same experience, backed up by numerous life tests, has shown that 6,000 hours is the average life of the factory installed lubrication. Several prototype models of a new fan are constructed for tests. There is no known reason why these motors should not follow the expected pattern (1 or 2% gradual dropoff out to about 5,000 hours followed by a steep slope through 50% reliability at 6,000 hours). Twelve prototypes are operated on a life test in which one had failed before 5,000 hours and seven more had failed between 5,000 and 6,000 hours. By adding a lot of subjectivity (experience) to a little test data, one can conclude that these motors are just as reliable as those previously tested.

Accelerated Life Testing. Accelerated life testing can be used within limits to help evaluate reliability. If we return to the previous example about fan motors, and assume that we have discovered that the insulation system can be caused to deteriorate 10 times as fast as normal at 140 C, we can use this as an established law to provide accelerated life testing of the insulation system on our fan motor. We then place 12 more prototype motors on test with high temperature grease in the bearings, and discover that the first insulation failure occurred at 3,500 hours and five before 6,200 hours. We can now conclude that our insulation system is probably good for at least 4 years of continuous service and an average of 7 years. In an 8-month test we have provided ourselves with 7 years of test data. If our past experience concerning the 10 to 1 ratio of insulation life at 140 C is correct, we have numerical insulation reliability data which we will call measured, but, of course, it is part subjective because this time the factor might have been 9 to 1 or 11 to 1 instead of 10 to 1. The accepted methods of statistical analysis for determining the quantity of data and the significance of conclusions must always be depended upon to provide reliability information.

If the shape of the curve cannot be derived by other means, it is essential to expend enough units in tests to measure it. This is both costly and time consuming but absolutely necessary if a true measure of reliability is desired. One object of measurement is to help reduce the area of subjective prediction by supplying quantitative information of reliability in all areas possible.

The period of life testing should correspond at least roughly to the intended life of the equipment. It should neither be much too long nor too short if good information is to be derived from the testing. If it is impractical to perform proper length life tests, then accelerated life tests can be used as the method of estimating the reliability, providing that the shape of the reliability curve is known and the law of acceleration is adequately established.

PARTS AND SYSTEMS

FROM PREHISTORIC TIMES, it has been recognized that "a chain is no stronger than its weakest link." Also, the mathematics for determining the relationship between parts failure and system failure has been known for a long period of time. It is not our purpose to discuss the mathematics but to review briefly the result of series and parallel parts operation on system reliability.

Series and Parallel Parts Definitions. If a system is assembled like a chain in which the failure of any one of the parts results in system failure, then the parts are in series. If the parts are arranged like the strands in a wire rope and the load adjusted so that any one strand will carry the whole load, then they are in parallel. Seldom does one find a system in which a large number of parts are in true parallel, inasmuch as parallel operation is most frequently used to provide increased load capacity rather than increased overload capacity. In a later section, it will be shown how even a few parts arranged for true parallel operation may suffice for many purposes. Most complex devices are not simply analyzed because they contain both parts in parallel and in series.

The following three analyses assume that the failures are independent so that the reliability of each part is uninfluenced by the others. This is highly improbable, but nevertheless leads to enough simplification to be worthy of study. In addition, seldom does one find a system in which the parts are of equal reliability. However, the following analyses are based upon equal reliability of parts arranged either for true parallel or series operation.

Series Parts. For a system arranged with all the parts in series, it is possible to write a simple relationship between the parts reliability and the system reliability. Let R_1 be the fractional reliability of the first series part. Let R_2 be the same for the second part, R_3 for the third, etc. It is apparent that the chances of simultaneously having two "in service" parts (i.e., good parts) is the product $(R_1)\ (R_2)$ for the first two parts and that it can be extended for all parts. Thus, for N series parts, the summation or system reliability $R_{\Sigma N}$ can be directly written as:

$$R_{\Sigma N} = (R_1)\ (R_2)\ (R_3)\ (R_4) \ldots (R_N) \qquad (1)$$

If $R_1 = R_2 = R_3 = \ldots R_N = R$ (i.e., if all parts have equal reliability equal to R)

then:

$$R_{\Sigma N} = R^N \qquad (2)$$

Curves of some useful values of $R_{\Sigma N}$ and R are given in Fig. 1.

Fig. 1 represents the relationship between parts and systems reliability for systems made up of true series parts of equal parts reliability. It will be noted that for system reliabilities over about 90%, the curves are straight lines, and that doubling the number of parts will double the systems unreliability. The discouraging thing about this curve is the magnitude of the numbers. One hundred series parts (even the simplest modern automobile has many times this number of parts in series) must have parts reliability of 99.95% for the system to have only 95% reliability and 500 series parts requires 99.99% parts reliability to get the same system reliability.

No matter how bad the parts, there is some small probability of success. Thus, 50 parts of 90% reliability provide ½% system reliability. From this it is evident that the reliability of the system cannot be assessed from a very small sample alone.

Parallel Parts. In a nearly homogeneous system (that is, one in which all the parts are nearly alike) the concept of a large number of elements in true parallel operation is easy. Thus, a steel rod can be replaced with several small ones in parallel, or can, itself, be considered as a large number of closely knit filaments in parallel. There are other ways to obtain the equivalent of parts in parallel. Trying several successive times to accomplish the same mission is one simple method of parallel operation. A dueling pistol in the hands of a novice is no match for a six-shooter in equally unskilled hands.

More complex systems make visualization of parallelism more difficult. An 8-cylinder automobile engine tends to have eight cylinders and parts in parallel for partial failure, but they are in series for total failure. If one spark plug fails, the other seven cylinders will carry

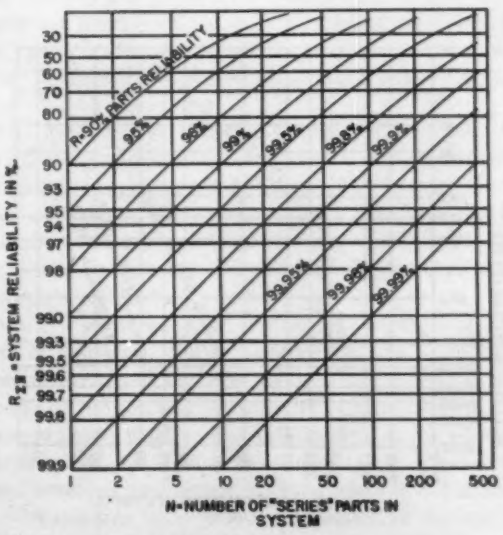

Fig. 1. System reliability for series parts.

some overload and continue to function. Thus, the action is similar to parallel operation. If one of the connecting rods fails or a piston sticks, all eight cylinders fail; thus the action is similar to series operation.

One of the major inventions of electronics systems was the process of negative feedback by which partial failure of one or more series parts in a system can be passed on to the other portions of the system in such a manner that the results obtained in many aspects resemble parallel operation. It should be noted that this is only achievable by having a reasonably large overload capacity in at least most of the portions of the system and preferably in all.

No matter how the parallel operation is achieved, the reliability of a system made up of parallel parts can easily be expressed mathematically. Let R_1, R_2, R_3 . . . and R_n be the fractional reliability of the parts in parallel. The fraction of parts that have become nonoperational then can be expressed as $C_n = (1\text{-}R_n)$. This can be called the part's unreliability. The system unreliabilities then can be written as:

$$C_{\Sigma n} = (C_1)\,(C_2)\,(C_3)\ldots(C_n) \tag{3}$$

If the parts all have equal unreliabilities

$$C_1 = C_2 = C_3 \ldots = C_n = C \quad \text{thus} \quad C_{\Sigma n} = C^n \tag{4}$$

$$R_{\Sigma n} = (1 - C_{\Sigma n}) = 1 - C^n \tag{5}$$

Plots of a few useful values of solutions to this equation are presented in Fig. 2.

If a system reliability of 99.0% is required using 100 parts in series, each part would need be 99.99% reliable. However, it could be replaced with 200 parts in series parallel, each one of which was 99.0% reliable or with 300 parts in series parallel, each of which was only 95% reliable. By applying parts in parallel only to the more unreliable parts in the system, it is possible to achieve system reliabilities which might otherwise be hopeless.

Parts Values. By applying the ideas presented in the previous paragraphs, it is possible to derive a minimum value for improved reliability. From equation 5 for parallel parts:

$$C^n = 1 - R_{\Sigma n} \tag{6}$$

If it is assumed that the minimum value of a part is equal to the number of identical parts in parallel that it can replace to provide the same system reliability, then the exponent n in equation 6 can be replaced with a value $= V$.

$$C^V = (1 - R_{\Sigma n}) \tag{7}$$

$$V = \log_C (1 - R_{\Sigma n}) = \frac{\log_e (1 - R_{\Sigma n})}{\log_e (1 - R)} \tag{8}$$

This can be expressed also as follows:

$$\text{Minimum Value} = \frac{\log_e (1 - \text{Final reliability})}{\log_e (1 - \text{Initial reliability})}$$

Plots of such minimum values have been prepared as Fig. 3. The study of this figure reveals that a 99% reliability part is worth no less than 3.8 times as much as a 70% part and that a 99.9% part is worth a minimum of three times as much as a 90% part. Further, a 99.99% part has a minimum worth of only two times that of a 99% part. It is simple to make great initial strides toward perfection by paralleling a few poor parts, but again it is soon found that final assurance of perfection is an elusive thing that cannot quite be purchased by paralleling imperfect parts.

The values listed in Fig. 3 are minimum values in the true sense of the word. They are based upon the alternative of simply paralleling parts. Almost never is it possible to parallel two or more parts without additional costs.

It should not be considered that these curves apply primarily to economic value. They can be applied to costs, weights, cubic volumes, or whatever characteristic is the controlling factor.

Since the analysis of series and parallel parts was based upon several simplifying assumptions the parts value equation is oversimplified too, but the concept is sound.

Heterogeneous and Homogeneous Systems. The previous discussions of parallel and series parts in a system were based upon the very unlikely system in which all the parts were equally reliable. System made up of nonuniform parts are far more likely and far more difficult to evaluate. A few brief remarks will suffice to explain such systems in a qualitative manner. For series operation of parts, it is well known that "one bad apple spoils the whole barrel." No amount of effort spent on the 100 strong links in a chain will prevent the weak one from breaking. Mathematically, this is not the whole story but if there is a seriously weak part, then the most effort should be directed to making it strong enough to suffice for the system before the stronger parts are worked upon.

The only problem remaining then is to be able to

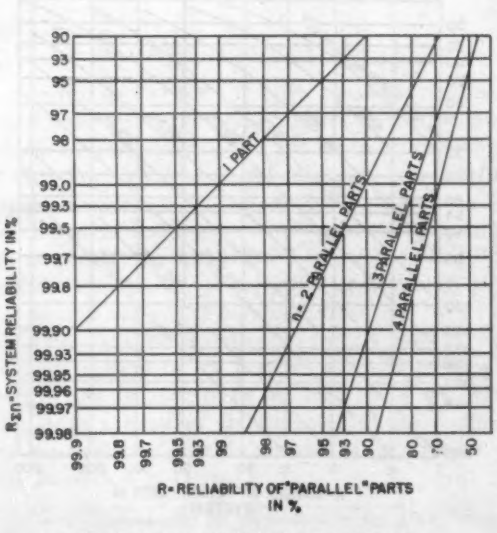

Fig. 2. System reliability for parallel parts.

define and select the weakest parts so that they can be singled out for effort. From the discussion on series parts we return to equation 1: $R_{\Sigma N} = (R_1)(R_2)(R_3)\ldots(R_N)$. The reliability of a first system made of parts can be written

$$R_{\Sigma x} = (R_1)(R_2)(R_3)(R_4)\ldots(R_x) \tag{9}$$

By replacing only the last of those parts with a reliability of R_y instead of R_x then:

$$R_{\Sigma y} = (R_1)(R_2)(R_3)(R_4)\ldots(R_y) \tag{10}$$

The ratio of these two system reliabilities is

$$\frac{R_{\Sigma x}}{R_{\Sigma y}} = \frac{(R_1)(R_2)(R_3)(R_4)\ldots(R_x)}{(R_1)(R_2)(R_3)(R_4)\ldots(R_y)} = \frac{R_x}{R_y} \tag{11}$$

Thus, it is evident that in a nearly homogeneous system, the ratio of the system reliability is the same as the ratio of any two comparable parts. Further, it is evidently true for heterogeneous systems also if "comparable parts" exist.

Thus, if one is to single out a part having 99.90% reliability and improve it to 99.99%, the system reliability might have been improved from 80.00% to 80.08%. In the same system, if one is to single out a part having 81% reliability and improve it to 86%, the system reliability would improve from 80.00% to 84.94%. In the latter case, the results of the effort is much more apt to be attractive.

In general, it can be concluded that the parts in a system that have contributed to the system failure will have attracted attention in rough proportion to their need for effort.

TESTING

THERE IS A WIDELY ACCEPTED ADAGE to the effect that quality cannot be tested into a product. It is true that the physical qualities of a product are seldom improved by testing, but such qualities as reliability are established only by testing (or the field experience which is in some ways the best test of all). Reliability is based upon confidence and trust in a product. Thus, this quality not only can, but should be tested into a product. Inasmuch as testing is such an integral part of the establishment of reliability, the previous discussions have contained several comments concerning proper testing. This important part of reliability should be reviewed again.

The complete testing of a device or system to establish its comparative reliability and to monitor the reliability during production is exemplified by the type testing and sample testing used in many military type specifications.

Object of Reliability Testing. It is imperative that two aspects of reliability be kept in mind during the devising and conducting of tests designed to establish and control reliability. The shape of the per cent in service vs time curve must be established during the type test and controlled during production testing. The tests must be so devised that any significant changes in the shape of this curve are brought to the immediate attention of the design and manufacturing agencies.

The over-all reliability during the entire period of time of use of the product must be established and controlled. Shortening the life test of the product is generally based upon the assumption that the shape of the reliability curve is known; sometimes, the assumption is that the life curve is exponential. This latter assumption is the equivalent of assuming that there is no wear-out mechanism active in the desired life period. Such assumptions can only be truly justified by actual tests, thus making it necessary to conduct some type of full length life test. It is sometimes possible to use quite small life test samples to detect wear out by examining in detail all failed parts.

Method of Testing. The accepted method of evaluating probable success or failure is to draw a small control

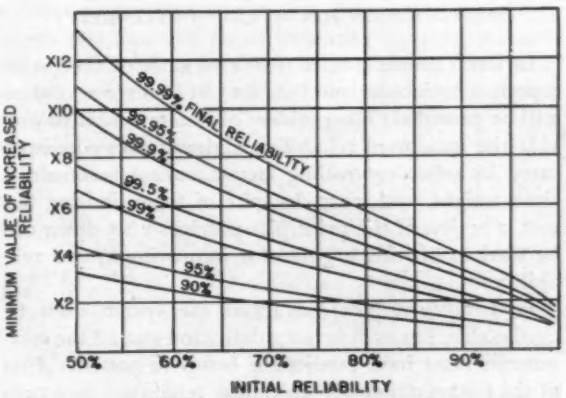

Fig. 3. Minimum value for improved reliability.

sample from a supposedly homogeneous family and assume by examination of the small sample, that the probability of each member of the family corresponds to the probability discovered. This method of test is far from perfect but provides the only known method of numerical evaluation. Since 100% life testing of a product would result in perfect test data but no products, only the method of scientific sampling can result in both products and confidence.

Life Testing. The design of life testing to provide the data for reliability curves must be carefully planned and executed. For example, life testing a few items (1 to 10) is an unsure method at best, but unless the shape of the reliability curve can be rather firmly established before the test is started, it is not only worthless but can be downright misleading.

Widely scattered data that is obtained from such tests is worthless except when combined with much more of the same. The effort should be concentrated in testing the largest feasible number of samples to a time interval that will provide a small safety factor over the intended life. Of course, this shortest test interval frequency becomes a lifetime; or even when much shorter, it is far too long to await the completion of the test before delivery of the equipment.

The use of accelerated life testing to shorten the test interval is an ever-present requirement. It is important to understand that such methods result in useful data only when the laws governing the life are well established. Thus, it can be seen that accelerated life testing is only truly applicable to comparatively simple devices or systems. Even at its best, this type of testing tends toward subjective reliability and will seldom provide good numerical reliability data. It does seem quite adequate for some comparative reliability testing. It is especially useful when several of each of two systems are subjected to identical accelerated life tests and the results compared. Such tests are only valid when both systems follow identical laws. Also, statistical evaluation of the significance of the test results is imperative.

SYSTEM DESIGN FOR MAXIMUM RELIABILITY

IN CONCLUSION, a brief review of each of the major aspects of reliability and how they fit into system design will be provided. The problem of system design to provide the maximum reliability is almost always complicated by other controlling factors, such as economics, time, weight, and space. In spite of these limiting factors, a review of the principles previously set down can be used to provide a guide for improving system reliability.

Predictability. Not only must the system itself be predictable, but each major subdivision and all the components must have predictable behavior patterns. Part of the system design for maximum reliability then calls for the education of the users, if necessary, as well as the search for the simplest methods of solution. If it cannot be easily explained in the instruction book, it probably will be subjectively unreliable.

Assessability. The system and its parts must have assessability. Simple provisions for attaching the necessary test equipment and sometimes the proper test equipment itself must be provided and adequately calibrated before reliability can be achieved. A simple straightforward set of specifications and test procedures must be provided as part of the system design before reliability can be guaranteed. All unnecessary intermediate specifications and junction point measurement must be deleted lest they result in unreliability of a complex system which would otherwise be reliable.

Parallel and Series Parts. A skillful blending of parallel parts interposed at the weak points in a system of series parts must be made. These "parallel parts" can be achieved in several manners not at first apparent.

Simple overload capacity of a weak part is the equivalent of parallel operation. A feedback system capable of automatically redistributing a portion of the burden of partial failure is somethimes equivalent to parallel operation. The application of the small difference theorem to the system design results in improved system reliability in a manner analogous to parallel operation. Null balance systems, servo systems, etc., apply this technique to achieve added measure of accuracy per unit reliability. The deliberate shifting of the major responsibility for system stability, or reliability to a component of known quality while enclosing the unknown or unreliable parts in a feedback loop or in some noncritical part of the system has the same effect as reducing the number of series parts. Careful examination of the system to determine which parts are in parallel and which are in series, must be made. As it was pointed out, a part can be in parallel for partial failure and in series for total failure. This is generally true of parts in feedback systems.

Homogeneous and Heterogeneous Systems. The adoption of as nearly a homogeneous system as possible will improve subjective reliability even if it offers nothing except the reduction in the number of laws, specifications, or tests. It can frequently provide improved measured reliability through better parts, better tooling, or better control of processing or manufacture.

Past Experience. For some systems, where it would be impractical to construct or test enough identical systems actually to measure the reliability, it is necessary to pattern the work closely on past experience. Thus, it is almost essential that such systems be more or less minor modifications of existing well-tested systems; or, at most, a fusion of several such highly reliable systems. By this means, the subjective reliability can be established by the pari-mutuel method.

Maintenance. Careful consideration must be given to the manner in which maintenance and adjustment effects reliability. A careful plan for periodic maintenance may be an essential part of system design. Even the definition of reliability is dependent upon the maintenance to be given the equipment. It should be noted that parallel operation or overload capacity can frequently be substituted for good maintenance (i.e., increased reliability) in a system that is properly designed. This is especially true for partial failures. For example, if two or more parts capable of overload are arranged in parallel and connected with independent fuses (or equivalent) then the failure of any one of them can be made to constitute only a partial system failure. The system will isolate its faulty parts automatically and, thus, be more reliable while requiring less immediate attention to maintenance.

SUMMARY

THE FIRST PART of this discussion covered mainly subjective reliability and some definitions. It was noted that subjective reliability must be created in the minds of the user and purchaser as well as measured reliability in the equipment, but it is self-evident that only properly designed equipment can ever succeed at becoming known as reliable. The designer can and must provide the potential reliability in his designs. The actual field reliability is a problem involving many other persons and factors. Such field reliability cannot be expected to rise above the work of the designer, but to achieve maximum reliability all available factors must be exploited, thus the designer does not stand alone.

Current-Carrying Capacity of ACSR

H. E. HOUSE
MEMBER AIEE

P. D. TUTTLE
MEMBER AIEE

THE CONTINUOUS current-carrying capacity of transmission lines is dependent upon the allowable temperature of operation of the conductors. A great deal of test work has been performed in the investigation of this problem on ACSR (aluminum cable, steel reinforced). However, two factors—the effect of the sun and of the altitude of the line—have not received consideration heretofore.

The effect of sun may be noted in appreciable sagging errors in the stringing of large conductors when air temperature rather than actual conductor temperature is used for determining the sag.

In the determination of a suitable method of calculation it is desirable, of course, to reduce arithmetical work to a minimum, but the simplification must not produce substantial errors. Transmission lines are often so long that weather conditions may vary widely from end to end, as may the amount of conductor weathering along the line. Thus, for example, if a part of the line is bright conductor in a sunny area and part is well-blackened conductor in a cloudy area, the permissible current will be determined by the bright-conductor section although, as may be seen from Fig. 1, the allowable current may be substantially greater, for the same total temperature, for the black conductor.

Another factor is the effect of altitude on temperature rise. At high altitudes, the heating effect of the sun is more pronounced and the cooling effect of the air is less, so that the capacity of high-altitude lines is reduced from what is an allowable load at altitudes close to sea level.

The electrical conductor laboratory of Alcoa Research Laboratories has made a large number of tests in order to obtain experimental data for checking the suitability of various formulas for determining temperature rise. The various factors—convection, radiation, conductor surface, sun effect—were then taken and combined into as simple a formula as would give computed results consistent with the test results.

The final formula is

$$I = \sqrt{\frac{\left[1.01 + 0.371\left(\frac{D\rho_f V}{\mu_f}\right)^{0.52}\right] k_f (t_c - t_a) + 0.138\, D\epsilon\left[\left(\frac{K_c}{100}\right)^4 - \left(\frac{K_a}{100}\right)^4\right] - q_s}{r}}$$

D = conductor diameter, inches
V = wind velocity, feet per hour
ρ_f = air density, pounds per cubic foot
μ_f = air absolute viscosity, pounds per hour-foot
k_f = air thermal conductivity, watts per square foot-degree C
t_c = conductor temperature, degrees C
t_a = ambient (air) temperature, degrees C
ϵ = emissivity constant of the conductor surface
$K_c = t_c + 273$, degrees Kelvin
$K_a = t_a + 273$, degrees Kelvin
q_s = heat gain from the sun, watts per square foot

The renewed interest in current-carrying capacity has been the result of a shift in the time of the yearly peak load. In many cases, the growth of air-conditioning load has resulted in more utilities having their peak loads in midsummer, when conditions for overloading are least favorable. For adequate design for these loads, reasonable knowledge of the sun effect is required, and this effect is considered here. At the same time, the other factors involved have been examined and a formula presented that may be used with confidence by the operating engineer in setting up permissible loadings and by the transmission engineer in the design of new lines.

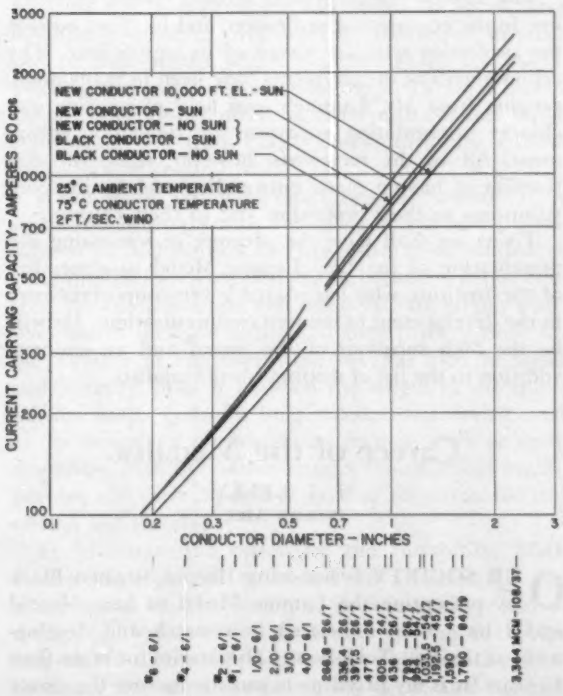

Fig. 1. Current-carrying capacity of ACSR with various surface and ambient conditions.

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H. E. House and P. D. Tuttle are with the Aluminum Company of America, Alcoa Research Laboratories, Massena, N. Y.

Harold S. Black

1957 Lamme Medalist

History of the Medal

H. I. ROMNES
FELLOW AIEE

THE LAMME MEDAL, being awarded to a distinguished member of the Institute today, was established by Benjamin Garver Lamme in his will. The purpose of the award is to give deserved recognition to a member of the Institute who has shown "meritorious achievement in the development of electrical apparatus or machinery." This achievement may be in any field of application.

In considering candidates for the award, the Institute has always exercised the greatest care to insure the fulfillment of Mr. Lamme's intent in establishing it. The type of "meritorious achievement" mentioned in the deed of gift is, therefore, very clearly defined. It is taken to mean an accomplishment that has resulted, or will result, in the production of substantially improved electrical apparatus or machinery. It may be the development of (a) theory, (b) characteristics of materials employed, (c) over-all design, or (d) other ways which provide substantial improvement in the indicated field. The "electrical apparatus or machinery" is defined as a "discrete and self-contained device," which may be part of a system, but not a whole system.

Benjamin Lamme was a brilliant design and development engineer—a modern pioneer in his field. His own accomplishments, which are well known and recorded, were recognized by the AIEE when he was awarded the Edison Medal in 1919.

In addition to his professional accomplishments, Mr. Lamme was a highly respected teacher of engineering in his company. It was his hope in instructing young engineers, not only to impart the benefits of his wide knowledge and experience (although this was certainly important), but to inspire in his students the desire to "look to the future" continually and consider obstacles merely as challenges to be met and overcome. If his philosophy can be stated in a single sentence, the quotation inscribed on the medal which bears his name, is that sentence. It reads, "The Engineer views hopefully the hitherto unattainable." This is the type of philosophy which breeds progress, and without which, many of the technological advances that are so much a part of our life and work today would not have been achieved. Indeed, the ability to look ahead—to design and build for the future—is a necessary attribute of the true engineer. He adhered to this ideal throughout his life, and in his will provided a means of giving suitable recognition to those who, like himself managed to attain the "hitherto unattainable."

The Lamme Medal is held in high esteem by everyone in the engineering profession, and by those outside the profession who are aware of its significance. The achievements of the recipients have been in many areas, ranging from Mr. Lamme's own field of rotating machinery to regulating apparatus and television equipment. All of the recipients, however, share the distinction of having made outstanding and lasting contributions to their profession and to their country.

Today we shall have the pleasure of witnessing the presentation of the 1957 Lamme Medal to a member of the Institute who has played a very important part in the development of modern communications. He will be the 30th recipient of the award and an eminent addition to the list of distinguished medalists.

Career of the Medalist

M. J. KELLY
FELLOW AIEE

OUR SOCIETY is honoring Harold Stephen Black by presenting the Lamme Medal to him. Harold and I have been associated in research and development at the Bell Telephone Laboratories for more than 35 years. It is my privilege to outline for you the career of my friend, Harold Stephen Black, our medalist.

Harold was born in Leominster, Mass., on April 14,

Presentation and acceptance addresses made at the ceremony awarding the Lamme Medal which was held during the AIEE Summer General Meeting, Buffalo, N. Y., June 22-27, 1958.

H. I. Romnes, American Telephone & Telegraph Company of New York, N. Y., is chairman of the AIEE Lamme Medal Committee.

1898. Upon completion of his training in electrical engineering at Worcester Polytechnic Institute in 1921, he entered the employ of the Engineering Department of the Western Electric Company. This organization became a part of Bell Telephone Laboratories, Inc., when it was formed in 1925. His entire professional career has been as a member of the research organization of the Bell System.

Harold's first field of work was in the development of transmission systems. He has been an active participant throughout his career in the research and development programs in the area of transmission and has made large and significant contributions to the evolving technology. He is endowed with one of the most creative and inventive minds of his generation of electrical engineers. His creativity and inventive genius have been continuous and sustained to this day. Some 55 United States patents are credited to him, and seven patent applications are now pending. Substantially all of his inventions have been applied in the development of facilities for communication usage. A major fraction of the transmission systems of communications and of radio and television broadcast transmitters and receivers are dependent on Black's inventions.

Although many of Harold's inventions have made great impact, that of the negative feedback amplifier is indeed the most outstanding. It easily ranks co-ordinate with De Forest's invention of the audion as one of the two inventions of broadest scope and significance in electronics and communications of the past 50 years.

The vacuum tube invented by De Forest and the negative feedback principle discovered by Black have made it possible to overcome the barrier of distance and to interconnect telephones throughout the world. Without the stable distortionless amplification achieved through Black's invention, modern multichannel transcontinental and transoceanic communications systems would not be possible.

When more and more amplifiers are connected in series as is necessary with increasing length of the transmission path, distortion and instability in the output of each amplifier are cumulative and become a major concern. Because distortion and instability are largely additive, unless they are minimized they place a limit on the number of amplifiers that may be used in series and, thereby, place a limit on the length of the transmission path. Today, a long transmission circuit such as one across the continent may include 1,000 or more amplifiers, each one introducing a thousandfold amplification and each capable of causing objectionable distortion and instability.

To eliminate the distortion and instability, Black took a small part of the output of an amplifier and connected it back to its input in reverse phase. In so doing, he reduced the distortion produced by the amplifier a thousandfold or more. This negative feedback also decreased the instability occasioned by such factors as variation in power supply voltage and electron tube aging. The negative feedback principle is now applied almost universally to amplifiers used for any purpose. It is no exaggeration to say that, without Black's invention, the present long distance telephone and television networks which cover our entire country and the transoceanic telephone cables would not exist.

The application of Black's principle of negative feedback has not been limited to telecommunications. Many of the industrial and military applications of amplifiers would not be possible except for its use. Many new weapons, such as radar direction of bombing and radar control of missiles, are dependent on negative feedback for their success. The development of servomechanisms theory and its application are extensions of Black's principle of feedback and are generally recognized as such. Thus, the entire explosive extension of the area of control, both electrical and mechanical, grew out of an understanding of the feedback principle. This principle also sheds light in psychology and physiology on the nature of the mechanisms that control the operations of animals, including humans, that is, on how the brain and senses operate.

Many of the researchers before Black were aware of the need for reducing amplifier distortion in order to permit the connection of large numbers of amplifiers in tandem. Their only approach, however, and indeed Black's first approach was to try to linearize the tube characteristic. I was in charge of electron tube research at the time that he was pursuing this course and co-operated with him closely in an endeavor to provide an adequate linear tube characteristic, but all to no avail.

In the course of this work, Black attended a lecture delivered by C. P. Steinmetz at an AIEE meeting and was impressed by Steinmetz's way of getting down to the fundamentals of a problem. As a result, Black restated his own problem as being that of removing distortion products from the amplifier output. Note that he had previously attempted to obtain amplification without distortion. He now turned to an acceptance of distortion in the amplifier output and asked himself how to eliminate these products. Following this line,

"For his many outstanding contributions to telecommunication and allied electronic arts, especially the invention of the negative feedback amplifier and the successful development and application of the negative feedback amplification principle."

M. J. Kelly is president of the Bell Telephone Laboratories, Inc., New York, N. Y.

he observed that by reducing the output to the same amplitude as the input and subtracting one from the other, he would be left with the distortion products only, which could then be amplified in a separate tube and used to cancel out the distortion products in the original amplifier output. Over a period of more than three years Black struggled with the problem, using approaches too complex for satisfactory application. Finally, a mathematical analysis convinced him that by merely inserting a part of the output power into the input in negative phase, he could obtain any desired reduction in distortion products at the expense of a sacrifice in amplification. His final mathematical analysis was conceived while he was crossing the Hudson River on the Lackawanna ferryboat en route from home to the Laboratories. He wrote the equations that led to the solution on the back of his newspaper.

In the course of Harold's career in research he has received many prizes and awards:

In 1934, he was awarded an AIEE prize for the "best paper on theory and practice" for his paper on "Stabilized Feedback Amplifiers."

He was honored in 1940 by the National Association of Manufacturers as a "Modern Pioneer" in "recognition of distinguished achievement in the field of science and invention."

In 1941, the John Price Wetherill medal of the Franklin Institute was awarded ". . . for his technical contribution to the efficiency of modern long distance telephony."

In 1946, a Certificate of Appreciation was awarded to him by the War Department in recognition of contributions during World War II.

In 1952, he received the annual award of the Research Corporation for contributions to science. This was in recognition of his many inventions, with the negative feedback amplifier given special mention, and his record of contributions in the communications field.

In 1955, Worcester Polytechnic Institute, his alma mater, awarded him an honorary degree of Doctor of Engineering.

He is the author of many technical articles and, in 1953, of a book called "Modulation Theory," which is regarded as the definitive writing on this subject.

While Harold has always been driven in his work by an unbounded enthusiasm and a dedication that brooks no interference to the solution of the problem at hand, the warmth of his personality, his charm, and the high level of his integrity have brought an ever widening circle of friends and admirers. As one of them, I congratulate him today on his receipt of this honored medal and tell him that we at Bell Laboratories know that there are contributions yet to come that will bring added distinction and new awards.

HAROLD S. BLACK (*center left*) **receiving the 1957 Lamme Medal Award from AIEE President W. J. Barrett** (*center right*) **as H. I. Rommes** (*right*)**, chairman of Lamme Medal Committee, and Dr. M. J. Kelly** (*left*) **look on.**

Invention in Engineering

H. S. BLACK
FELLOW AIEE

I AM DEEPLY HONORED and grateful to be awarded the 1957 Lamme medal. Throughout the years, the high prestige and importance of this award have been augmented by the outstanding creativeness and distinguished achievements of previous award winners. It is indeed a great privilege to be included among those so highly honored by the Institute and it is with much pride and humility that I accept the Benjamin Garver Lamme Medal.

I sincerely feel that acceptance of this award is an acknowledged tribute to my many colleagues whose efforts and co-operation contributed so much to the success of the many achievements that Dr. Mervin J. Kelly has enumerated. I feel, too, that Dr. Kelly's generous praise and expression of friendship have indeed profoundly enriched this great honor of today. And of this I am sure: in a large measure any success or accomplishment of mine is because of my good fortune in being associated with an organization that provides opportunity and support; factors which contribute greatly to an environment designed to encourage creative thinking, invention, and discovery.

Invention in engineering is a broad topic so my remarks will be confined to the 20th Century American trend. The past 50 years have witnessed the rapid growth of a procedure for fostering invention and discovery. This procedure is organized teamwork characterized by a programmatic approach. The team is a group of scientists and engineers of proved ability. Industry has applied this teamwork procedure to a wide variety of functions, including: fundamental scientific and engineering research; design and development of apparatus and equipment; and design and developmet of complete operating systems. There seems little doubt of the success of this method in large industrial, university, and governmental areas where tried.

An individual inventor, working for a large organization, finds an ideal environment when he is a member

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of an organized team and is in situations that confront him with a great variety of problems. Here, he can consult at a moment's notice with any one of hundreds of famous authorities in diverse fields; each day he is stimulated by his many professional contacts with his immediate colleagues who have similar scientific and engineering interests; and at all times he has access to the services of well-equipped laboratories, instrument bureaus, various kinds of shops, drafting facilities, numerous types of computing machines, libraries, transcription departments, and all manner of helpful services. Last but not least, company records which may go back many years are at his disposal.

These and other factors may be illustrated by my own experiences. In retrospect, the story of how the negative feedback amplifier originated, the development of the negative feedback amplification principle, and related events stand out as good examples and amplify what Dr. Kelly has said.

The idea that the creation of a better amplifier would be a good problem to attack happened back in 1923. Motivated by a desire to improve existing amplifiers, I noted that a vastly superior amplifier characteristic was required in order to achieve far-flung carrier telephone systems having many amplifiers in tandum, each amplifier handling many channels. Eventually, this broad problem was reduced to the fundamental one of an amplifier output having an unwanted component not present in the input. That this unwanted component could be reduced or suppressed was demonstrated experimentally. Actually, this demonstration circuit did not use negative feedback and had serious practical disadvantages.

However, satisfied that a solution was theoretically possible, a search was started for an innovation that would simplify the circuit and perfect its operation. One morning, I suddenly experienced a complete understanding[1] of how to achieve this difficult objective and, as Dr. Kelly has told you, it happened on the Lackawanna Ferry in the year 1927. I felt an urge to write but had nothing to write on so picked up my morning paper. By sheer coincidence one page was blank. Here was a perfect set-up, lots of room and fully dated. With this to implement my job, I started the first written record pertaining to the stabilized negative feedback amplifier. Years of study and many failures preceded this sudden conception of stabilized feedback. Despite immediate recognition of its importance, years of additional work were required before it found substantial commercial use.

Very simple mathematics and analytical methods sufficed to explain the negative feedback amplification principle and the many remarkable properties of the negative feedback amplifier. Little time was lost before these predictions had been verified by experiment and explored in considerable detail. When this material was incorporated in the patent application[2] it became unusually long. The reason for its extraordinary length is that the invention was in a new field, the principles of which were contrary to certain statements in the then current literature. Thus, the patient had to teach a new art: the negative feedback amplification principle.

Pertinent to invention in engineering is the familiar experience that invention fosters research and vice versa. In this instance, the demonstrated importance of the negative feedback amplifier prompted new researches by Nyquist and Bode.

It was appreciated from the beginning that, under wrong conditions, a feedback amplifier would develop dangerous instability. After learning that my rule for avoiding this unhappy result was conjectured to be more restrictive than necessary. Dr. Harry Nyquist[3] suggested a more general rule. His rule has become known internationally as the Nyquist criterion. Although this criterion is simple in expression and application, Nyquist's derivation of it required a mathematical–physical intuition given to few men.

Dr. Hendrik W. Bode spearheaded a group of professional mathematicians who developed systematic techniques of design suggested by him[4,5] whereby one could get the most out of a specified situation and still satisfy Nyquist's criterion.

During the past 19 years, there has been a growing recognition that the mathematics of the negative feedback amplifier and the negative feedback amplification principle are directly applicable to simple servomechanisms, provided the system is approximately linear. Carried over into the field of automatic control, this entire body of mathematics, in effect, fertilizes an old field. Ultimately, applications that these extensions will open up may be of preponderant importance.

These reminiscences illustrate that inventions solve problems, that sometimes one invention may be the genesis of hundreds that follow, that upon occasion an invention may lead to the discovery and development of a new principle, that invention fosters research and vice versa leading to advance after advance, that the present-day programmatic approach with its organized teamwork both stimulates and encourages contributions by individual inventors, and last, that the importance of an invention is measured by the difficulty and significance of the problem it solves. The most important technological advances imply solutions to the most difficult problems of our times and, in our concentrated, persistent, enthusiastic efforts to resolve these problems we find everlasting encouragement and inspiration in Lamme's own words:

"The Engineer views hopefully
the hitherto unattainable."

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Short-Circuit Tests on Bundle Conductors

A. L. MALMSTROM
MEMBER AIEE

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J. O. SMITH

Corona losses in transmission lines may be reduced by the use of two or more conductors per phase, an arrangement often referred to as bundle conductors. Tests made to determine stresses on spacers between these conductors are described.

LONG DISTANCES and ever-increasing difficulties in securing rights of way for transmission lines have made it necessary to resort to higher operating voltages. The Detroit Edison Company is presently constructing an extrahigh-voltage line. Such lines present a problem of conductor design because of corona losses and radio interferences. These losses can be reduced by increasing the conductor diameter, thereby lowering the dielectric stress at the conductor surface.

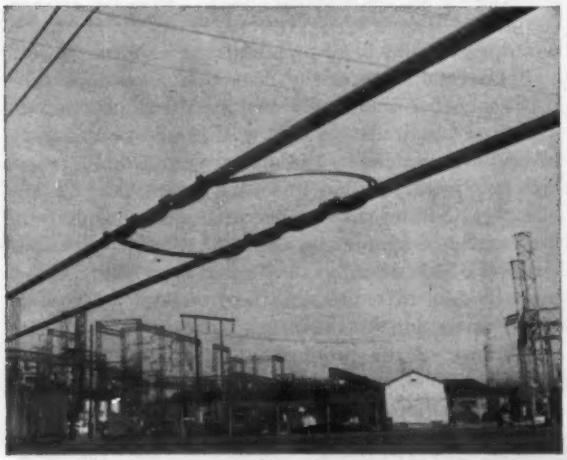


Fig. 1. Preformed type of spacer mounted on test span.

Various methods have been used for increasing the diameter without increasing the amount of metal; for example, the use of hollow conductors and expanded conductors. One type of the latter has a filler, such as paper or hemp, between the steel core and the outer layers of aluminum.

Full text of District paper 58-508, presented at the AIEE Great Lakes District Meeting, East Lansing, Mich., May 5-7, 1958.

A. L. Malmstrom, L. G. Gifford, and J. O. Smith are with The Detroit Edison Company, Detroit, Mich.

The authors wish to acknowledge the valuable assistance of A. E. Featham, R. W. Burke, and J. Howe of The Detroit Edison Company in the preparation of the field setup and instrumentation for the tests described.

Another method by which corona losses can be reduced is to use more than one conductor per phase. This arrangement, referred to as a bundle conductor, usually consists of two, three, or four cables, with the twin type most prevalent. For a given voltage the individual conductors in a bundle are smaller as the number of conductors is increased. They are electrically connected to one another and are usually spaced from 14 to 18 inches.

Advantages of a bundle conductor over a single conductor of the same total cross section are

1. Reduced corona losses and, therefore, less radio influence.
2. Greatly reduced reactance and increased system stability.
3. Reduced inductance and increased capacitance, resulting in an increase in the power transfer capacity of the line.

Electrical forces on the bundle consist of electromagnetic attraction, which is proportional to the square of the current, and electrostatic repulsion, which is proportional to the square of the voltage. The electromagnetic force predominates at heavy current, and when large enough (short-circuit conditions) the conductors will contact each other. Spacers between the conductors, installed approximately 200 feet apart in the span, are required to maintain bundle spacing. These spacers are expected to prevent the conductors from wrapping around each other under fault conditions and also when there is intermittent dropping of ice. However, the conductors may contact each other between spacers unless they are installed at closer intervals.

It is difficult, if not impossible, to calculate the forces resisted by the spacers under short-circuit conditions. Because no satisfactory test data were available on these spacers and the forces to which they are subjected under faults, it was decided to set up a test span to measure them. Special instruments were designed to measure these forces. In addition, the action and performance of various types of spacers under short-circuit conditions were witnessed and recorded on film with motion picture cameras.

TEST EQUIPMENT AND PROCEDURE

Test Equipment. In order to test the line spacers under simulated field conditions, a special 400-foot single-phase bundle span was erected of two 954-MCM (thousand circular mil) 45/7 ACSR (aluminum cable, steel reinforced) conductors spaced 16 inches apart. The

return line was offset horizontally 6 feet and vertically 13 feet and was of the same construction. The tension in each conductor at the time of testing varied from 6,500 pounds to 7,000 pounds because of changing temperatures during the day of the test. To approximate actual conditions, a spacer was placed in the center of the 400-foot span with the ends of the span rigidly anchored and considered as spacers. This was equivalent to the spacer arrangement being considered for future line construction. In Fig. 1, one type of spacer that was tested is shown mounted on the test line.

Test current was obtained by using a spare 24-kv position at Warren Station (one of the higher sources of fault current) to feed four 3,333-kva, 24/4.8-kv single-phase transformers connected in parallel. The transformers were fed from the 24-kv position by means of 300 feet of 350-MCM cable. The secondary of the bank of transformers was connected to the test line through a special secondary switch. The closing of the secondary switch was controlled by a synchronous timer which closed the switch at voltage zero to obtain maximum current offset. The 24-kv breaker was pretripped so that the duration of the fault current was approximately five cycles, which is the expected breaker time plus relay time on the extrahigh-voltage line. The magnitude of the test current was varied by changing the number of transformers connected in parallel. The point of voltage at which the secondary switch was closed and the fault current were recorded by means of an oscillograph.

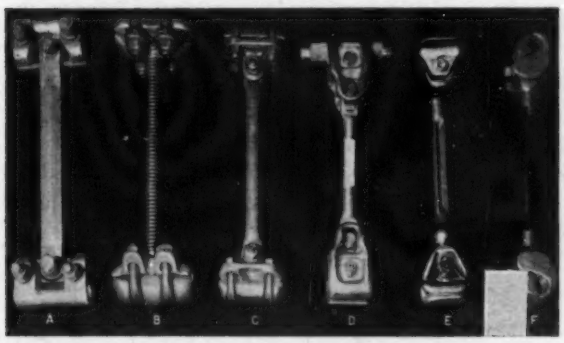


Fig. 2. Some of the different types of spacers available.

Test Procedure. A total of six tests were conducted, in which measurements were made of force on an instrumented spacer installed at the center of the span. In all but one of these tests, a strain-gauge dynamometer was employed to record the compressive force due to electromagnetic attraction between the conductors and tension due to conductor rebound. These measurements were made at four values of current, approximately 8,000, 13,000, 15,500, and 18,500 symmetrical amperes, respectively. An additional test was subsequently conducted, at a current of approximately 18,500 amperes, in which the maximum compressive force was measured by means of a deflection gauge.

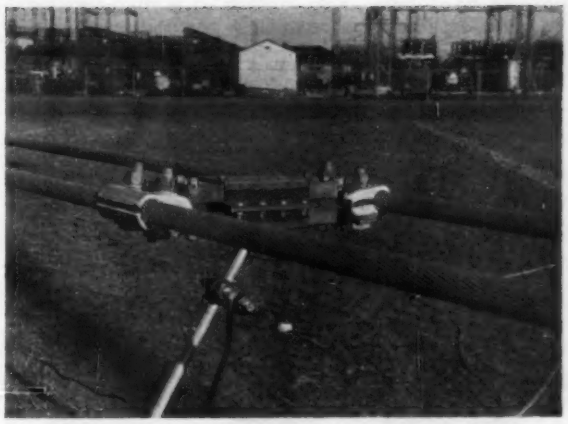


Fig. 3. Spacer incorporating strain-gauge dynamometer.

A series of additional tests were performed in which several spacers of various design were each installed at the center of the test span and subjected to fault currents of various magnitudes. At least one test was conducted on each type of spacer at the maximum current of 18,500 symmetrical amperes, with maximum offset. No force measurements were made in these tests. Measurements were made of the dimension between the conductors at the spacer location to determine whether permanent deformation occurred in the spacers. These spacers, except the preformed type, are shown in Fig. 2. Two other types of spacers which were not tested are also shown.

Force-Measuring Instrumentation. Two types of force-measuring devices were employed to measure the forces imposed upon a spacer by short-circuit currents. One was a strain-gauge type dynamometer incorporated in a

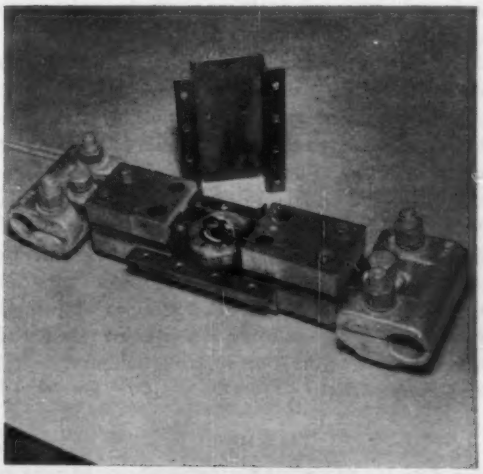


Fig. 4. View of strain-gauge dynamometer showing details of magnetic shielding.

modified spacer. By recording the output of this dynamometer on an oscillograph, a complete record of the force throughout a given test could be obtained. The second type was a proving-ring type deflection gauge that measured only the maximum compressive force on the spacer.

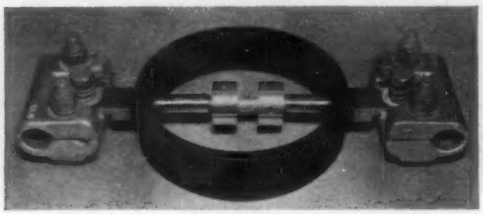


Fig. 5. Deflection gauge used for measurements of maximum compressive force on spacer.

The modified spacer containing the strain-gauge dynamometer is shown, as it was installed between the conductors, in Fig. 3. A view of the dynamometer with the shielding partially removed is shown in Fig. 4. The force-sensing element is a machined steel ring to which four resistance type strain gauges are bonded. The strain gauges are connected together in a push-pull type bridge circuit, such that the bridge output voltage is proportional to either tensile or compressive loading on the ring.

One problem encountered when strain gauges are employed in the presence of electromagnetic fields of intensity is that of eliminating large spurious 60-cycle currents in the strain-gauge circuit. Such effects were minimized in this case by the provision of ⅛-inch thick steel shielding around the strain gauges and wiring. The details of the shielding can be seen in Fig. 4. The dynamometer was connected to the recording equipment by means of 300 feet of shielded microphone cable. The cable was enclosed in thin-wall conduit in the proximity of the conductors as a further precaution against spurious pickup.

The deflection gauge is shown in Fig. 5. This gauge was constructed with a shaft extending inward from one side of an 8-inch diameter steel ring and centered in a hollow tube attached to the other side of the ring. Prior to a test, a sliding collar on the shaft was positioned in contact with the end of the hollow tube. Compressive loading on the ring caused the sliding collar to be displaced toward a fixed collar on the shaft. The maximum displacement was determined by inside micrometer measurements of the dimension between the sliding and fixed collars. The maximum compressive load was determined from a calibration relating load and deflection of the sliding collar.

TEST RESULTS

THE EXTRAHIGH-VOLTAGE LINE is expected to have a maximum fault current of approximately 20,000 symmetrical amperes with a maximum momentary offset of 1.58 times the symmetrical value. Maximum current obtained in this test was 18,500 symmetrical amperes with average offset of 1.4 times the symmetrical value.

The results of the six tests in which force was measured are shown in Fig. 6, showing a plot of the compressive force on the spacer against symmetrical current. The maximum force recorded was 485 pounds, corresponding to a symmetrical current of 18,500 amperes.

A typical oscillograph record of current, spacer force, and the point on the voltage wave at which the fault was applied is shown in Fig. 7. The symmetrical current for this test was 15,500 amperes. The current was interrupted after 4½ cycles. Approximately 0.04 second after interruption of the current, the conductors contacted at locations between the spacer and the ends of the span. This event is characterized by high-frequency oscillations of short duration on the force trace. The maximum compressive force of 330 pounds occurred 0.07 second later. The subsequent rebound of the conductors produced a maximum tensile force of 320 pounds on the spacer. In all tests, the maximum tension imposed by rebound of the conductors was approximately equal to the maximum compressive force on the spacer.

During the period of current flow, the compressive force on the spacer increased at an approximately uniform rate. The 60-cycle variations visible on the force trace of the oscillograph record prior to interruption of the current represent small spurious induced currents in the strain-gauge circuit, the result of imperfect magnetic shielding of the dynamometer.

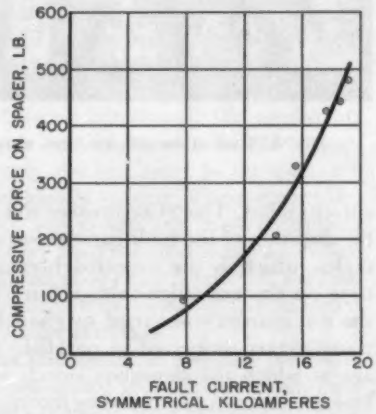


Fig. 6. Compressive force on spacer vs fault current.

With the exception of one type, all the spacers that were tested were found to have no noticeable deformation from the forces imposed as the result of fault currents. The spacer that was unsatisfactory consisted of a length of stranded cable between two clamps. This type permitted the two conductors to contact each other at the spacer clamps when subjected to the compressive force accompanying the high current flow. After one maximum current test, the stranded cable of this spacer was permanently deformed.

Another spacer, of the preformed type, was subjected to the forces resulting from test currents of 13,000 and 16,000 amperes, followed by three tests at 18,500 amperes each with maximum offset. After these tests, the spacing of the conductors at the spacer location was reduced from 16 inches to 15⅝ inches. Another preformed spacer of the same type was subjected to two high-current tests, with no noticeable deformation.

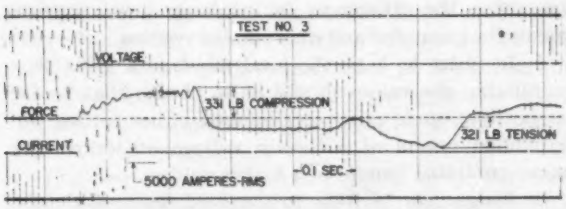


Fig. 7. Typical oscillograph record of force variation.

CONCLUSIONS

1. The maximum compressive force exerted on 16-inch spacers installed at 200-foot intervals is of the order of 500 pounds for fault currents of approximately 20,000 amperes. The force increased approximately at the square of current.

2. The tensile force exerted on spacers as the result of conductor rebound is approximately equal to the compressive force caused by electromagnetic attraction.

3. All except one of the spacers that were tested were found adequate, from a strength standpoint, to resist the forces imposed by short-circuit currents of up to approximately 20,000 symmetrical amperes having maximum offset. The type that was not adequate consisted of a piece of stranded cable between two clamps.

Standard Basic Impulse Insulation Levels

AIEE COMMITTEE REPORT

Since the issue of a report on basic impulse insulation levels in 1941, additional information regarding system grounding practices and maximum operating voltages has been made available. This new report provides recommended values applicable to equipment for use on grounded and ungrounded a-c supply systems.

IN 1951, the AIEE–EEI–NEMA Joint Committee on Insulation Coordination, after more than 10 years of study, issued a report (Edison Electric Institute Publication No. H-8; National Electrical Manufacturers Association Publication 109; *Electrical Engineering*, vol. 60, March 1941, p. 121) which recommended a series of standard basic impulse insulation levels (BILs), 30 kv through 1,550 kv, inclusive. These recommended standard BILs have received wide acceptance and are serving a very useful purpose. However, since the 1941 report was issued, additional data have been made available regarding system grounding practices and maximum operating voltages. In addition, there has been substantial operating experience with equipment having reduced insulation strengths. These data and experiences warrant a re-examination of these BIL values to determine whether changes or additions are required. Also, the trend toward the use of higher transmission voltages makes it desirable to determine whether higher values should be added.

SCOPE

THIS REPORT provides recommended standard BIL values applicable to equipment for use on grounded or ungrounded a-c supply systems. These basic impulse insulation levels are those which have general application and are considered suitable for adoption as American Standard values.

OBJECTIVES

INSULATION CO-ORDINATION has for its objectives the establishment of standard BIL values and the specification of insulation strengths of electric equipment in terms of standard insulation levels, when such equipment is applied among the preferred nominal system voltages (taking into consideration usual operating conditions and variations in system grounding practices). It is expected that the standard BIL values will con-

A report by the AIEE Standards Co-ordination Committee No. 8, recommended for publication by the AIEE Standards Committee.

The personnel of the AIEE Standards Co-ordinating Committee No. 8 are: J. H. Foote (chairman), H. W. Collins, L. W. Gross, E. M. Hunter, T. G. A. Sillers, E. C. Starr, J. J. Taylor, C. F. Wagner, Byron Evans, K. E. Hapgood, K. H. Kidd, S. C. Killian, J. R. Meador, C. W. Miller, J. M. Towner, and F. J. Vogel.

stitute one of the bases for insulation strength standards for many types of equipment. The specific application of these standards to this equipment is expected to be embodied in the standard specifications for the equipment in question.

DEFINITIONS

DEFINITIONS of certain terms relating to insulation co-ordination have been adopted by the Joint Committee and are given herein to clarify the meaning and intent of this report.

1. Co-ordination of insulation is the process of correlating the insulation strengths of electric equipment with anticipated overvoltages and with the characteristics of surge protective devices.
2. Withstand voltage is the voltage which electric equipment is capable of withstanding without failure or disruptive discharge when tested under specified conditions.
3. Rated withstand voltage is the voltage which electric equipment is required to withstand without failure or disruptive discharge when tested under specified conditions.
4. An insulation level is a voltage value expressed in terms of a withstand voltage.
5. An impulse insulation level is a voltage value expressed in terms of an impulse withstand voltage.
6. A basic impulse insulation level is the crest value of the impulse voltage which electric equipment is required to withstand without failure or disruptive discharge when tested with a standard 1.5x40-microsecond full wave.
7. A standard BIL is a basic impulse insulation level which has been adopted as a standard value in this report.
8. Impulse protection level is the maximum impulse voltage expected at the terminals of a lightning protective device under specified conditions.

BASIC PRINCIPLES

THE BASIC PRINCIPLES followed by this committee provide the background of the work which has been done and an understanding of its purposes. Briefly stated, these are:

1. BILs are designated in terms of the crest value of a 1.5x40-microsecond full-wave impulse voltage test wave.
2. The maximum system voltage affects the voltage rating of the surge protective device that can be used and the maximum value of the tolerable zone is the governing value.*
3. The general principle of insulation co-ordination requires a suitable margin between the impulse protection level that may be held by a surge protective device and an associated basic impulse insulation level.
4. The basic impulse insulation level tabulation recognizes the differences in insulation level requirements for grounded and ungrounded systems.
5. In order to keep the total number of BILs to a minimum, the values should be so chosen that, as far as possible, each value can be used either for an ungrounded system of a certain voltage or for one or more grounded systems of a higher voltage.
6. Assignment of BILs to standard items of electric equipment should be the function of those industry committees having jurisdiction over standards for such equipment.
7. Equipment represented as conforming to basic impulse insulation level requirements shall be capable of demonstrating such conformance by suitable tests.
8. The standard techniques to be used in tests for determining conformance of equipment to requirements of basic impulse insulation levels are under the cognizance of the appropriate industry committees.
9. The user should be the judge in the selection and application of accepted standard basic impulse insulation levels to his systems.

PROCEDURE

THE ESTABLISHMENT of standard BILs requires the determination of the impulse protection level which can be provided by surge protective devices for each system voltage for the system grounding practices most commonly in use. It includes consideration of the maximum system voltage and a determination of the maximum line-to-ground voltage (both at power frequency) expected during faults or abnormal system condition. This maximum line-to-ground voltage determines the minimum voltage rating of the surge protective device that should be used. The impulse characteristics of the surge protective device determine the impulse protection level at its terminals, and the impulse insulation level of equipment should exceed this protection level by a suitable margin.

Usually, the surge protective device is a lightning arrester, and the voltage rating of the selected lightning arrester is generally equal to the maximum line-to-ground voltage expected to be impressed upon it. For example, when such maximum line-to-ground voltage approximates the maximum system line-to-line voltage, the arrester having such voltage rating is designated as one having a 100 per cent rating, or it may be called a "100 per cent arrester." Similarly, arresters having other voltage ratings such as 80 per cent and 75 per cent of the maximum line-to-line system voltages, respectively, are called 80 per cent and 75 per cent arresters, respectively.

BASIC DATA

THE BASIC DATA and philosophy for the determination of maximum tolerable operating voltages expected

* For this report the values of the maximum voltage of the tolerable zone, as enumerated in Table I of American Standard on Preferred Voltage Ratings for A-C Systems and Equipment C84.1, have been postulated. Although this American Standard does not include nominal system voltages above 230 kv, its terminology and philosophy were used in selecting the higher nominal system voltages contained in this report. The maximum voltage of the tolerable zone, therefore, has been considered as being 5 per cent above the nominal system voltage for all voltages above 69 kv.

are provided in American Standard on Preferred Voltage Ratings for A-C Systems and Equipment, C84.1, issued in 1954. These maximum tolerable operating voltages together with the information provided by the third report of the AIEE Subject Committee on Present-Day Grounding Practices (AIEE *Transactions*, vol. 66, 1947, pp. 1525-48) have been used to determine the voltage ratings of lightning arresters generally applicable to the various system voltages for grounded and ungrounded systems.

The surge voltage which can appear at the terminals of a lightning arrester is determined by the impulse sparkover characteristic and the discharge voltage across the arrester during discharge of surge current. Significant reductions have been made in the sparkover and discharge voltage characteristics of lightning arresters since the 1941 report was prepared. In accordance with national standards, the impulse sparkover voltage characteristics of lightning arresters are based on a voltage wave having a rate of rise of 100 kv per microsecond per 12 kv of arrester rating. The discharge voltage characteristics are based on discharge currents having crest values of 10x20-microsecond current waves. In arriving at the standard BIL values given in this report, maximum values of impulse sparkover voltage and discharge voltage at a given current have been considered.

MARGIN BETWEEN IMPULSE PROTECTION LEVELS AND BILS

In addition to using maximum values of impulse sparkover voltage and discharge voltage of lightning arresters in the determination of standard BIL values, it is also necessary to include a margin between the impulse protection level and BIL of equipment. This is due to several factors, the more important ones being:

1. Departure of arrester performance from postulated characteristic values because of
   (a) The magnitude of discharge current being higher than the postulated value.
   (b) The rate of rise of discharge current being higher than that of the test current wave.
2. Potential difference between the lightning arrester terminals and the protected equipment. This is a function of such factors as
   (a) Separation distance between the arrester and the protected equipment and the effective lead length to the arrester.
   (b) Electrical surge characteristics of associated connections and equipment.
   (c) Resistance of lightning arrester ground connections.
3. Variations in equipment and system conditions.

NUMBER OF STANDARD BIL VALUES

The list of preferred system voltages provides a broad indication of the steps of standard BILs that may be required. However, differences in the maximum voltage of the tolerable zone, variations in grounding practices, and the differences in surge protection usually provided for various types of systems and equipment, all tend to result in a multiplicity of BIL steps. A careful balance must be achieved between the advantages gained by the standardization of a few well-chosen levels and the cost of providing a somewhat higher insulation level than might be required for certain conditions. In addition to the insulation level required for proper insulation co-ordination, certain minimum levels result from practical designs or may be required to meet other conditions such as corona, radio interference, insulation life, abnormal dynamic voltage, and switching surges. These factors have been taken into consideration in arriving at the recommended standard steps.

STANDARD BIL VALUES

Table I provides a list of the standard basic impulse insulation levels which have been adopted as a result of this work. They are expressed in terms of the crest value of a 1.5x40-microsecond full impulse voltage test wave and recognize the differences in insulation level requirements for the preferred nominal system voltages and present-day neutral-grounding practices.

Table I. Standard Basic Impulse Insulation Levels*

30	95	350	825	1425
45	110	450	900	1550
60	150	550	1050	1675
75	200	650	1175	1800
	250	750	1300	

*Withstand crest value in kv of a standard 1.5x40-microsecond full-wave impulse.

NONSTANDARD BIL VALUES

It is recognized that the standard BIL values in Table I may not apply to all equipment. BIL values are not now specified in the standards for the low-voltage windings of transformers for furnaces, synchronous converters, and rectifiers; for rotating machines; nor for industrial control and other low-voltage equipment.

Also, while it is expected that the values of Table I will be selected for nearly all equipment standards, there will unavoidably remain certain cases where limited exposure to damaging overvoltages, types of insulation, economic, and other considerations justify nonstandard BIL values. This is recognized in the accepted BIL requirements for some types and ratings of lightning arresters; 600-volt roof, floor, and wall bushings; and dry-type distribution and power transformers. Standard BILs may not apply to equipment having integral surge protective devices. The BIL values specified in the standards for such equipment are not sufficiently accepted to justify their inclusion in the table of standard BILs.

Coded

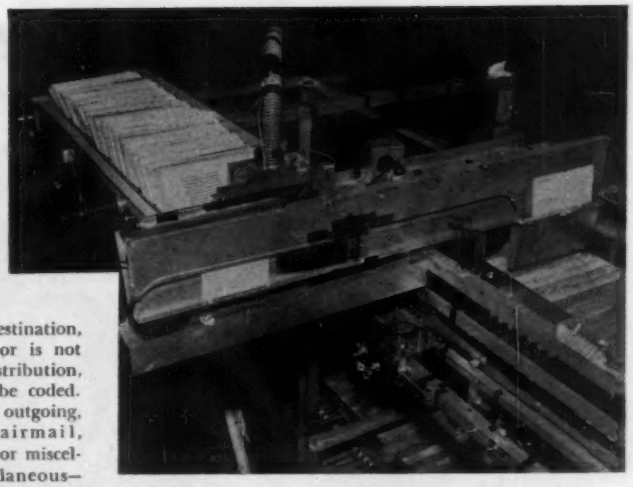
AUTOMATIC, high-speed letter mail sorting is being done by a laboratory prototype machine developed by Rabinow Engineering Co., Takoma Park, Md., sponsored by the U. S. National Bureau of Standards (NBS) for the U. S. Post Office Department (PO). Designed to sort at a 36,000-letters per hour rate into many categories, directed either by built-in electronic control, human operators, or a combination of both, the system is of modular design and, thus, adaptable to the varying sorting complexity and spatial requirements of different post offices. The machine has proved successful in laboratory tests, and the PO recently ordered construction of a 1,000-pocket production prototype.

Two basic problems are involved in mechanized letter sorting—first, the information content of the address and the mechanics of the control that must be provided by some computer-like device for directing the mail sort; second, the physical handling of mail. The envelopes used today and their contents obviously are not designed for mass machine handling.

Work on these problems at the NBS has proceeded along several lines. Data have been and are being collected in representative cities to form an engineering basis for the system and machine design. These data include such items as the general nature of the mail, i.e., size and shapes of envelopes, percentage of handwritten vs typewritten mail, and range of color of envelopes; number of letters handled daily and their distribution by times of day; and nature of distribution of local and outgoing mail. Studies are under way on methods of converting the written or printed address into a code printed on the envelope either with visible or invisible inks, or with magnetic materials. Development of special phosphorescent inks for this use is also in process.

Over-all view from three angles of the Rabinow laboratory prototype machine is seen in the first three pictures on this page. It consists essentially of a large number of pockets on an endless conveyor. Electromechanical equipment controls the dropping of a letter from a pocket into a specific fixed receptacle. As can be seen, 14 pockets are grouped together into a single unit for convenient conveyor handling. Accompanying each conveyor pocket is a steel rod carrying 12 nylon wheels. Each wheel can be shifted laterally on the rod into one of two positions. Thus, there are 2^{12}, or 4,096, combinations of wheel positions. As the conveyor moves, each set of 12 wheels rolls over tracks designed to drop into depressions when the correct destination is reached, thus releasing the letter.

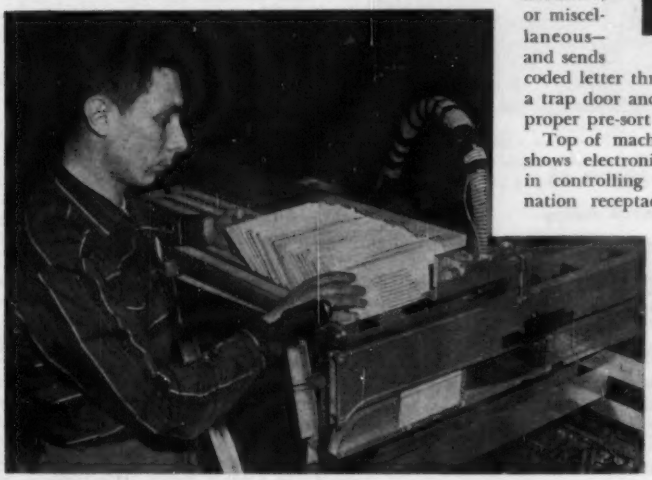
Mail Sorting



The mechanical sorting and coding of letter mail begins at the code printer, where letters from a stack of "faced" mail, moved by a conveyor belt, are picked off one at a time and mechanically placed in a reading-and-coding position in front of an operator (*lower left*, p. 730). Addresses are read and abbreviations typed on the backs of envelopes by means of a special printer.

Binary form print coding, requiring 6 bits for each alphanumeric character, codes outgoing mail merely by abbreviating city and state. Choice depends on whether all coding is to be done at initial location or part at final destination, and on whether the city to which letter is addressed is or is not equipped with automatic machinery. In sorting for local distribution, city need not be mentioned, and only street address need be coded.

Operator chooses one of four possible destinations—local, outgoing, airmail, or miscellaneous—and sends coded letter through first sort. Mechanism actuated by push button opens a trap door and sets a directing vane so that coded letter drops into proper pre-sort when it is released from code printer.



Top of machine (*two notched pictures*) where coded mail is placed shows electronic "reader" which scans the dot code and is instrumental in controlling the delivery of the coded letter to its particular destination receptacle. The reading head is located in the reader-feeder-inserter mechanism immediately preceding point where letter is dropped into conveyor.

Electronic directory (memory or translator) receives coded, abbreviated address, "looks up" sorting destination, and controls delivery to that destination receptacle. Electronic directory output drives code wheel setter which sets each group of code wheels on conveyor carts to appropriate coded arrangement to drop letter in final sort receptacle. Entire sequence involved is accomplished in approximately one-tenth second. Two close-up views (*bottom center* and *below center right*) show conveyor pockets with their associated code wheels.

An electromechanical-optical device (*lower left*, this page) especially designed to meet requirements of the sorting machine, the electronic directory converts the 64-bit code information into a 12-bit code corresponding to the conveyor receptacle. The directory consists of a stack of 64 thin plates of stainless steel, each approximately 1 foot square. Each plate has etched into it 40,000 small round holes, about 1/30th of an inch in diameter, spaced on 1/16-inch centers. Plates are so suspended that they can be moved electromagnetically 1/16 inch from left to right. Opaque black ink fills the holes. Some holes are punched out for directory address conversion data.

When the code contains the conventional full 64 dot positions, if each plate moves to the right when the dot is present but remains stationary when the dot is absent, then each address will cause the plates to move into a unique set of positions. Phototubes, each scanning a 3- by 4-inch area of the plate stack, permit the light to reach any desired combination.

Destination receptacles (*lower right*) are seen at bottom of machine into which letters are sorted. Special provisions enable conveyors to be stacked in various arrays so that letters can transfer from one conveyor to another for multiple sorting. It is possible to sort letters by short conveyors and use several successive sorts. The memory in its present form could handle a city of 100,000 to 200,000.

INSTITUTE ACTIVITIES

AIEE Pacific General Meeting Offers Program of Wide Interest

THE 1958 AIEE Pacific General Meeting to be held in Sacramento, Calif., August 19-22, will offer a program and activities that will appeal to all interests. Headquarters for this meeting will be the Hotel Senator. A rich and interesting technical program is assured. Six inspection trips of both general and technical interest including a trip to one of the world's largest rocket plants, will complete the program. Excellent, diversified entertainment is planned for the ladies, and special activities for students will round out the schedule. Arrangements have been made to accommodate the children of parents wishing to attend.

Historic Sacramento, capital of California, serves as a gateway to nearby points of interest—San Francisco, Lake Tahoe, Yosemite National Park, and Reno, Nev. Geographic and climatic advantages of Sacramento combined with other outstanding tourist attractions in Northern California offer an excellent opportunity to combine a business trip to the meeting with a family vacation.

General Session

At the general session, to be held in the Empire Room of the Hotel Senator, Tuesday morning at 10 a.m., members will be addressed by AIEE President L. F. Hickernell. Featured speaker will be C. C. Whelchel, chief mechanical engineer, Pacific Gas & Electric Company, who will discuss "Future Thermoelectric Power Plants on the System of the Pacific Gas Electric Company." H. O. Banks, director, California Department of Water Resources, will discuss "Power in the California Water Plan."

Technical Sessions

The highlight of this four-day meeting will be the technical program, notable for a variety of subject matter as well as timely and interesting papers. A tentative schedule of technical sessions follows. (Titles of papers will be published at a later date.)

Tuesday, August 19

9:00 a.m. General Session

2:00 p.m. Afternoon Sessions

Rotating Machinery and Relays
Computing Devices
Power Generation

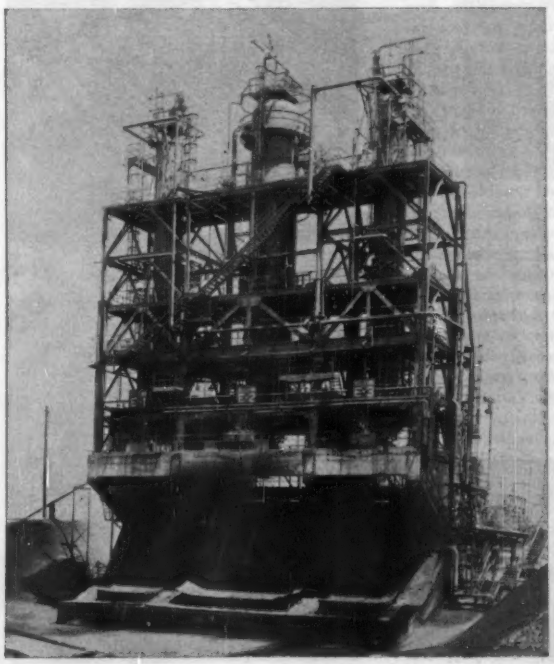
Wednesday, August 20

9:00 a.m. Morning Sessions

Industrial Power Systems
Nucleonic and Radiation Instrumentation
Domestic and Commercial Applications

2:00 p.m. Afternoon Sessions

Industrial Power Systems
Insulated Conductors
Domestic and Commercial Applications



ROCKET ENGINE test stand of Aerojet-General Corporation's Sacramento plant. Producers of equipment for the Vanguard, Polaris, Bomarc, and Regulus missiles, this plant will be visited during an AIEE Pacific General Meeting inspection trip.

Thursday, August 21

9:00 a.m. Morning Sessions

Feedback Control Systems
Substations
Radio Communication Systems

2:00 p.m. Afternoon Sessions

Feedback Control Systems
Transmission and Distribution
Wire Communication Systems

Friday, August 22

9:00 a.m. Morning Sessions

Transmission and Distribution
Power Systems Communications

Social Activities

Relaxed informality and fun are to be featured in the entertainment program. Early arrivals and their wives will be welcomed at an informal "Get-Acquainted" gathering in the Gold Room of the Hotel Senator on Monday evening from 7 to 10 p.m. The Gold Room is conveniently close to the registration center.

On Tuesday morning, a coffee hour from 8:30 to 9:45 a.m. in the Gold Room will precede the opening general session. Men, ladies, and students are invited. On Tuesday evening, an exciting Wine Tasting Festival is planned from 6 to 8 p.m. in the Empire Room of the Hotel Senator. There will be no charge for this event which will offer generous samples of a wide variety of world-famous California wines.

A limited number of Wednesday night tickets, which will be sold at $2.40 on a first-come, first-served basis, have been reserved at the Music Circus for the stage production, "The Most Happy Fella." Produced by the outstanding Lewis and Young Theatrical Company and held outdoors under a gala circus tent, this novel theatre-in-the-round musical will fascinate both men and ladies.

A Thursday luncheon featuring an outstanding speaker will be held for men and ladies at 12:15 p.m. in the Mirror Room of the Elks Club. W. H. Pickering, director of the Jet Propulsion Laboratory, California Institute of Technology, will speak on the subject "An Electrical Engineer Looks at the Space Age." Tickets are priced at $2 each.

Climaxing the entertainment program will be an authentic Hawaiian Luau at the Newman Club, Thursday evening. A complimentary cocktail hour will take place from 7 to 8 p.m. The Luau will be served by hula girls and beach boys from 8 to 9 p.m. to the accompaniment of native Hawaiian music and entertainment. Dancing to the American music of Clyde Mitchell will follow until midnight. Charge for the evening will be $6 per person.

Registration

The registration desk will be located in the entrance lobby of the Hotel Senator. Facilities for registering will be available Monday evening from 7 to 10 p.m., on Tuesday beginning at 8 a.m., and daily throughout the meeting.

For convenience, members and nonmembers should return the advance registration card sent with their mailed announcement. Registration fees payable at the meeting are $5 for members and $8 for nonmembers. Wives, children, and students will not be charged a fee.

Mailed Announcement

A mailed announcement of this meeting will be sent to members in AIEE Districts 6, 8, and 9. If a copy is desired by members in other Districts, please write to E. C. Day, Assistant Secretary for Technical Papers and Programs, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

Ladies' Activities

The ladies attending the meeting are sure to enjoy the interesting and fun-packed program planned for them. In addition to the social activities for both men and ladies previously listed, the following events have been especially prepared for the ladies. A coffee hour will be held Wednesday and Thursday mornings at 9 a.m. in Room 240 of the Hotel Senator. Room 340 will serve as "hospitality headquarters" each morning and other posted times for those who wish to play cards or relax.

Tuesday will offer a tour of the California Governor's mansion, followed by an afternoon tea at the famous Crocker Art Gallery. Busses will leave at 1 p.m. from the Hotel Senator. Cost will be $1 per ticket.

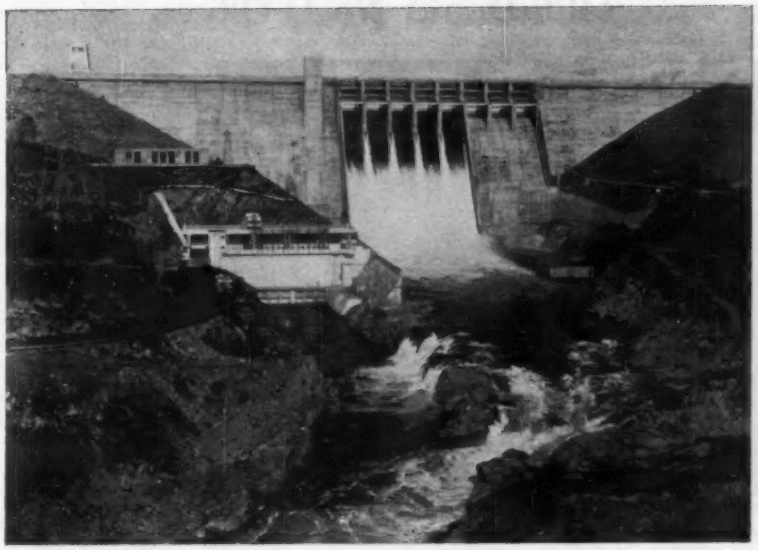
At 12:30 p.m. on Wednesday, a luncheon will be held at the fashionable Sacramento Inn. Featured will be a talk by Mrs. Joyce Peters, an unusually competent and charming lady engineer. A discussion of the aims and objectives of the Sacramento AIEE Wives' Club will follow. Tickets will be priced at $2.

On Thursday, the ladies are invited to join the men for a trip to the Tide and Oxydol Plant of the Procter & Gamble Company. Women will be escorted on an especially arranged visit of the plant. Transportation cost for the bus which leaves the Hotel Senator at 2 p.m. will be $1 per person.

Friday will feature a brunch with swimming and bridge. A nominal charge of $2 will be made for this event which begins at 10 a.m. at the El Mirador Hotel.

Inspection Trips

An outstanding program of inspection trips of both technical and general interest has been arranged. Interested persons are urged to make arrangements at the inspection trips desk immediately after registration. All trips are scheduled for half-days only and the return to headquarters will be in time for succeeding events. Men will be more comfortable on the trips if they plan to wear sport shirts. Special chartered busses have been secured for the trips. Those attending must ride these busses to gain admission to the facilities to be inspected.



FOLSOM DAM AND GENERATING FACILITIES. Rain and snow melting from the Western slopes of the Sierra Nevadas drive three 54,000-kw generators. The dam and powerhouse will be seen during one of the inspection trips planned for the AIEE Pacific General Meeting.

Aerojet-General Corporation (Bus leaves Hotel Senator Tuesday, 1:30 p.m., August 19). Located just a few miles from Sacramento, this company is believed to be one of the largest rocket production facilities in the world. Producers of equipment for the Vanguard, Polaris, Bomarc, and Regulus missiles, this plant, which covers 20,000 acres and employs 7,000 people, will provide a most unusual tour. Ticket—$2.

McClellan Air Force Base (Bus leaves Hotel Senator Wednesday, 8:30 a.m., August 20). Largest of the West Coast air materiel centers, this Air Base warehouses, maintains, and supplies Air Force equipment for the Western Continental and Pacific areas. Vital in time of war, McClellan serves now as a major bulwark of the nation's West Coast defenses.

Seen on this trip will be the Air Force's world-wide communications center and the jet overhaul, maintenance, and modification shops. Planes that normally can be seen on the flight line will include the *F86, F100, F104, B47,* and the large *RC121.* Ticket—$1.50.

Elverta and Hedge Substations (Bus leaves Hotel Senator Wednesday, 1:30 p.m., August 20). Elverta Substation is a principal receiving substation of the Sacramento Municipal Utility District (SMUD) at which power is taken from the U.S. Bureau of Reclamation (USBR) at 230 kv. Two 185,000-kva 3-phase 4-winding double autotransformers supply both 115-kv and 69-kv station buses. Four 12.5-mvar switched capacitor banks are connected to the 69-kv station buses. These banks are owned and operated by the USBR for transmission voltage control.

Hedge Substation is now under construction and most of the physical plant will be in place by the time of this trip. This station will receive power from the Pacific Gas & Electric Company and SMUD's Upper American River Hydro Project at 230 kv. Both the 230-kv and 115-kv buses are of the ring type. The initial installation includes one 230/120-kv, 120,000-kva 3-phase and one 230/76-kv, 160,000-kva 3-phase transformer. The approach used in the design of the steel structures is quite unique because it forms a zigzag pattern. Ticket—$2.

United States Army Signal Depot (Bus leaves Hotel Senator Thursday, 8:30 a.m., August 21). The mission of the Sacramento Signal Depot is to acquire, store, repair, and issue the many thousands of pieces of equipment used in communications by the U.S. Army. Equipment seen during the tour may range in size from a huge mobile radar set weighing many tons to a small transistor, only fractions of an inch in length.

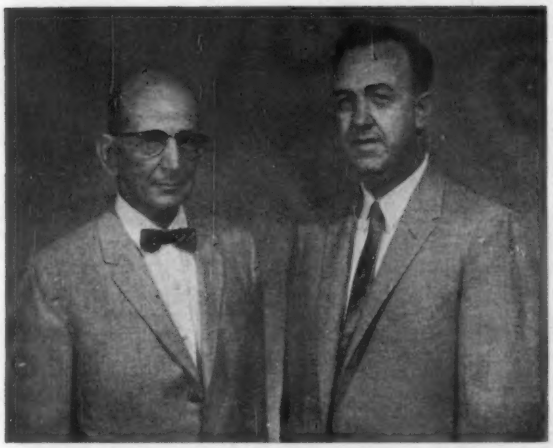
The Sacramento Signal Depot acts as a distributor, stocking items for Alaskan ports, and the Far East Command, and may ship to any part of the world.

The Maintenance Division repairs all types of signal equipment and maintains special shops for radar, electronics, avionics, neucleonics, communication, television, teletypewriter, meteorological, and radiological equipments.

An unusual feature seen on the trip will be the modern crystal grinding and fabrication shops. In this operation, crystals used in various communication equipments are shaped and ground with great precision. Ticket—$1.

Procter & Gamble Plant. (Bus leaves Elks Club Thursday, 2 p.m., August 21). This newest Procter & Gamble (P&G) plant manufacturing synthetic detergents and processing the raw materials used in them is located a short 20-minute bus ride from meeting headquarters. In the process area, tank car quantities of coconut oil are daily processed for shipment to all P&G plants in the United States making detergent granules, bars, and liquids. The

AIEE District No. 13 Officers



C. P. KNOST *(left)* **will serve as vice-president and M. L. Hurstell** *(right)* **will be secretary of the newly formed South Central District No. 13 of the Institute, established August 1, 1958.**

synthetic detergent plant is an integrated operation continuously converting liquid and solid chemicals into the familiar granules for home use.

Numerous automatic controls, both pneumatic and electronic, are used to control the chemical processes. The packing unit which will be seen on the tour has the latest in automatic packaging machinery and materials handling equipment. The 106,000-square-foot warehouse has the most modern palletless unit-load equipment for handling local production plus the full line of company products which are distributed to Northern California, the Pacific Northwest, and overseas. Steam for process use is supplied by two 60,000-pounds-per-hour boilers in a modern outdoor installation. The 12-kv distribution system to unit substations will be shown as part of the tour. Ticket—$1.

Folsom Dam and Powerhouse—Old and New (Bus leaves Hotel Senator Friday, 8:30 a.m., August 22). Visited during this tour will be the recently constructed Folsom Dam and generating facilities. The dam, completed in 1956 by the U.S. Corps of Engineers, impounds 1 million acre-feet of water. The power plant at the foot of the dam which houses three generators of 54,000 kw each, was installed and is operated by the USBR.

These generators supply electricity to the Central Valley Project whose 230-kv transmission lines traverse Northern and Central California. The generators, the step-up substation and switchyards, and a water pumping plant will be included as part of the trip.

A significant highlight of the tour will be attendance at a brief ceremony dedicating the original Folsom Powerhouse as a California Historical Landmark. Originally set in operation in 1895, Folsom was one of the first commercial hydroelectric powerhouses to deliver power at a high voltage to a distant city. In its heyday, 3,000 kw, generated at 800 volts, was transmitted at 11 kv for the unheard of distance of 22 miles to Sacramento. The plant was operated continuously until 1952 when construction of the new dam forced it to shut down. The old plant will be open for a brief inspection after the dedication ceremony. Ticket—$2.50.

Hotel Reservations

Rooms have been set aside at the Hotel Senator (meeting headquarters), two other downtown hotels, and three outlying motor hotels for members and guests attending the meeting. Since summer tourist traffic is heavy in Sacramento, those who plan to attend the meeting should submit their requests for room reservations immediately. Any rooms not spoken for by August 12 will be released for use by the general public. Rooms should be requested directly from the hotels, and the hotels will reply directly to the applicants. The room requests should mention specifically the AIEE meeting.

The daily rates for rooms with private bath at the various hotels are:

Hotel Senator, 12th and L Streets, Sacramento, (meeting headquarters)

Single	$ 7.00-$ 9.00
Double—two people, one bed	9.50- 12.00
Twin—two people, two beds	10.00- 15.00
Suite	25.00- 45.00

El Mirador Hotel, 13th and N Streets, Sacramento, (three blocks from meeting headquarters)

Single	$ 7.00-$14.00
Double—two people, one bed	9.00- 16.00
Twin—two people, two beds	10.00- 16.00
Suite	24.00- 30.00

Californian Hotel, 800 I St., Sacramento, (seven blocks from meeting headquarters)

Single	$ 5.50-$ 6.00
Double—two people, one bed	7.00- 7.50
Twin—two people, two beds	8.00- 9.00

Capitol Inn Motel, 1130 W. Capitol Ave., West Sacramento, (one mile west of meeting headquarters)

Double—two people, one bed	$ 9.00-$10.00
Twin—two people, two beds	10.00- 12.00

El Rancho Motor Hotel, 1029 W. Capitol Ave., West Sacramento, (one mile west of meeting headquarters)

Single	$ 6.50-$ 8.50
Double—two people, one bed	7.50- 10.50
Twin—two people, two beds	8.50- 12.50
Suite	20.00- 25.00

El Dorado Motor Hotel, 877 Canterbury Road, North Sacramento, (three miles east of meeting headquarters)

Single	$ 7.50-$ 9.50
Double—two people, one bed	11.00- 12.00
Twin—two people, two beds	11.00- 12.00
Suite	18.00- 24.00

Hawaii Post-Meeting Tour

An especially planned eight-day post-meeting tour to Hawaii has been arranged. Honolulu-bound members may fly from Sacramento at 9 a.m., August 23, and arrive in the Islands at 4:30 p.m.—with plenty of time for an evening swim at beautiful Waikiki.

On Monday, August 25, the Hawaii Section of AIEE will sponsor a one-day program consisting of a general get-together session followed by luncheon, inspection trips, and an evening social event for both ladies and gentlemen.

Except for the nominal charges for the inspection trips and the AIEE sponsored social events, the remainder of the stay and the air transportation will be included in the all-expense tour which is being quoted at $345 per person.

Those interested in this special feature are urged to write at once for complete detailed information to R. N. Keen, c/o General Electric Company, Forum Building, Sacramento, Calif. It is important that final arrangements and reservations be made not later than August 9.

Student Activities

In addition to other meeting activities, a special students' and counselors' luncheon is planned for Wednesday noon in Room 240 of the Hotel Senator. Dr. R. D. Bennett, manager of General Electric's Vallecitos Atomic Laboratory, will address the group. A short period will be allowed after the meeting for discussions of mutual interest. There will be no charge to students or counselors for the luncheon.

Inspection trip tickets may be purchased by students in attendance at the meeting for the low price of 50¢ for each trip.

Transportation

United Air Lines and Pacific Air Lines have several flights each day from all directions to and from Sacramento.

The Southern Pacific Company and the Western Pacific, with interconnections with major rail lines, serve Sacramento directly. Trips on the Santa Fe which stop at Stockton, Calif., 45 miles to the south, can be continued by bus, rail, or airline to Sacramento.

Sacramento lies at the crossroads of two major transcontinental highways, U.S. 40 and U.S. 50, and the major Pacific Coast inland route, U.S. 99.

Sports

A golf tournament is scheduled for Thursday afternoon at the Haggin Oaks Golf Course. This is truly one of the most beautiful courses in Northern California. Trophies will be awarded for low gross and low net scores, and there will be special prizes for the "duffer" class. Lunch will be served at the Club House as the first foursome will tee off promptly at 1 p.m. Greens fees will be $3.50 per person.

General Information

Weather in Sacramento in August is quite warm througout the day but requires a light wrap for evenings.

General information may be obtained at the registration desk. Mail may be addressed c/o Hotel Senator and should be claimed at the hotel desk.

A bulletin board will be provided for posting notices and special messages. Provisions may be made for baby sitting and child care. Various forms of recreation are available for children of all ages.

Enthusiastic Attendance at National Telemetering Conference

THE EIGHTH ANNUAL National Telemetering Conference was held at the Lord Baltimore Hotel, Baltimore, Md., June 2-4, 1958, with an enthusiastic attendance of 625. The sponsoring technical societies were AIEE, American Rocket Society, Institute of Aeronautical Sciences, and the Instrument Society of America (ISA). Active support was provided by the National Academy of Sciences—in connection with the program for IGY (International Geophysical Year)—and the Military Services.

During the three days of the Conference, technical sessions were conducted on industrial, mobile air and ground, and medical telemetering; two sessions were devoted to telemetering in the IGY program; other sessions covered pickups, transistors, data processing, and system problems. A classified session was held at Fort Holabird, Md., at which telemetering and instrumentation problems were considered.

Luncheon meetings were enjoyed on the first two days of the Conference. On Monday, Gen. Earle Cook, chief of research and development, U.S. Army Signal Engineering Laboratories, spoke on "Telemetering Requirements of the U.S. Army." After telling some historical facts about how the Army has used telemetering, he said that future warfare would be different from anything that we have seen and that the military would be more dependent than ever before on obtaining all types of information from a distance. One of the more important factors mentioned was obtaining weather information as far in advance as possible. Another was the dispersion of enemy troops and what they were doing; this could be secured from televised airborne equipment of a robot character. Gen. Cook urged his listeners to give earnest thought to the many military problems of telemetering which he outlined.

Dr. Robert Jeffries, president of Data Control Systems, Inc. and the ISA, addressed the Tuesday luncheon. He called for a new unity of purpose and objectives among technical societies in order to do a better job in education and research, information dissemination, and conference techniques. He urged the use of workshop seminars along with individual talks and a new concept of programming to bring genuine scientific information to wider audiences.

Rear Adm. Blinn Van Mater, USN (retired), administrative officer of the U.S. Committee for IGY, was the speaker at the banquet held Tuesday evening; his subject was "Telemetering in the IGY." After outlining the objectives being sought during this 18-month period in which 66 nations and 10,000 scientists are participating at an approximate cost of $500 million, he stated, ". . . telemetry is playing an important part in each field of science being observed; in some areas it is playing an essential role. Only with the aid of telemetry and high-speed communications can the gathering of synoptic data be so extensive around the earth, in the earth, and above the earth. When the information is digested, theories will have been proved, revised, or scrapped completely, opening the door to further exploration."

Following Adm. Van Mater's address, excellent entertainment was enjoyed by the banquet guests. Equally enjoyable were the three inspection trips: on Tuesday afternoon, the Applied Physics Laboratory of the Johns Hopkins University was visited; on Wednesday, there was an all-day trip to the Aberdeen Proving Ground's Ballistic Research Laboratory, and in the evening a visit to the Martin Company, the prime contractor for the Vanguard Rocket. The entertainment for the ladies included a visit to McCormick's House of Spice, a fashion show, and a sightseeing trip around Baltimore.

Leading manufacturers in the telemetering field showed and demonstrated their latest equipment. Many of the exhibits tied in with technical papers, which provided an opportunity to see the equipment as well as hear how it is used.

Technical Sessions

Some 70 papers were presented at the 14 technical sessions and the spirited discussions following most of the presentations indicated the great interest of the audience.

The five papers given in the session devoted to medical aspects of telemetering were of special interest. One of the outstanding presentations was by W. F. Sutterer, J. W. Kirklin, and E. H. Wood, all of the Mayo Clinic, concerning the monitoring and continuous recording of physiologic variables during intracardiac surgery. In all, 23 variables were monitored, among them being respiration, arterial and venous pressures and oxidation, and body temperature, together with an electrocardiogram and an electroencephalogram. There were eight variables recorded: pressures in the arterial line to the patient and in the venous line from the patient; rate of blood flow to the patient and over the mechanical lung; oxygen saturation; the pH and temperature of the arterial blood supplied to the patient from the machine. Many of these variables involved the use of special transducers of the most delicate order, since they had to be introduced into the heart itself.

During two sessions devoted to IGY telemetering, the subjects ranged from the instruments installed in the satellites now in space to their tracking by the "fence" of radio stations from the United States to Chile. An interesting paper, "The IGY Program at Ballistic Research Laboratories," was presented by R. E. Prenatt. After giving the historical background of the two previous international "years" and stating what world scientists hope to discover during the one ending next December, he described the instrumentation at Fort Churchill where rockets are tracked by three infrared cameras at three different nearby points and four DOVAP (Doppler Velocity and Position) stations. He explained the DOVAP telemetry system, which operates on 38.031 mc, and how with it the accurate trajectories of the missiles can be found.

"Bathymetry Telemetry" was the subject of a paper by J. M. Snodgrass, Scripps Institute of Oceanography. Using a bucket and a thermometer, Benjamin Franklin traced the Gulf Stream and drew a map of its course, which was remarkably accurate with present-day charts. This 18th-Century oceanographer was among the first in the United States. This phase of science has become very important, although comparatively little known. Telemetry has become an important factor in determining the pressure, temperature, and other characteristics of the oceans' depths. New electronic instrumentation, thanks to Lord Kelvin's introduction of steel wire, enables oceanographers to use electronics as a telemetering aid today, but the speaker emphasized that new ideas were necessary to ascertain the data which many companies are demanding at the present time.

In a session on mobile ground telemetering equipment, Lt. Col. D. H. Vicek, Air Force Missile Development Center, N. Mex., showed a color moving picture describing the telemetering instrumentation of the 35,000-foot high-speed missile test track at Holloman AFB, Alamogordo, N. Mex., and its operation.

The papers presented at this Conference have been published and can be obtained for $4 from Order Department, AIEE, 33 W. 39 St., New York 18, N. Y.

The committee chairman for this Conference were as follows: W. J. Mayo-Wells, technical program chairman; G. M. Thynell, chairman—National Committee; Mrs. G. H. Carden, ladies activities; R. R. Longwell, entertainment; T. E. Meyers, exhibits; T. H. Marshall, Jr., publicity; E. T. Loane, attendance; P. L. Betz, chairman—Local Committee; S. Taborsky, meetings; L. R. Heise, field trips; G. P. Stout, vice-chairman—Local Committee; W. B. Mann, secretary-treasurer; and T. W. Chase, registration.

Wear Your ◆ AIEE Badge

Manuscript Guide for the Author of a Transactions Paper

1. *Author's Guide.* Each prospective author should obtain a copy of the 1957 "Author's Guide" from the Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y., before proceeding with the preparation of a paper.

2. *Transactions Papers.* Formally reviewed technical papers, judged on the basis of permanent reference value, for publication in the Institute's official *Transactions.*

3. *Manuscript of Paper.* Should be typed on one side only of 8½- by 11-inch white paper. Use new black typewriter ribbon and clean type. Erasures are unacceptable on original copy.

Copies required: Original plus three reproductions.
Spacing: Single-spaced text, double-spaced between paragraphs.
Title: CAPITALS, underlined, centered at top of page.
Section headings: CAPITALS, centered.
Margins: ½ inch at top and sides, and 1 inch at bottom.
Page numbers: Centered in top margin.

4. *Equations.* Those that cannot be typed should be in black ink.

5. *Figures and Illustrations.* Copies required: Original tracings plus three prints. All drawings, curves, etc., must be drawn in black india ink on tracing cloth or on good quality tracing paper.

6. *Blueprints.* Acceptable for copies only and not as originals.

7. *Lettering.* On all drawings, lettering should be large enough so that, when reduced in size in printing, the letters will not be less than 1/16-inch high.

8. *Captions of Figures.* Captions are never reproduced from the lettered drawings. They should be typed on a separate page, each one in a block 3¼ inches wide, and separated by at least 2 spaces. These are cut out and placed in an appropriate place with the figure when the manuscript is reproduced.

9. *Due Date for Manuscripts.* Usually, the manuscript is due 90 days prior to meeting where it is to be presented. For official closing dates, see the Institute Activities Section of the latest issue of *Electrical Engineering.*

10. *Send Copies to:* E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.

11. *Review.* Papers are reviewed by the cognizant Technical Committee(s). Papers must meet Institute requirements as described herein.

12. *Presentation.* All Transactions papers must be presented at a regular General or District Meeting, or Special Technical Conference. When author submits paper, he should indicate meeting at which he wants it presented.

13. *Preprinting.* Prior to the meeting at which they are presented, accepted papers are preprinted by the Institute for distribution, at cost, to interested persons.

14. *Discussions.* If a written discussion of a Transactions paper is to be published with the paper, it must be submitted (three copies, double-spaced) to Mr. Day within two weeks after the meeting. This discussion need not have been presented at the meeting.

15. *Author's Closure.* Authors are usually asked to reply in writing (closure) to written discussions of their papers.

16. *Publication.* After presentation, the complete manuscript, together with written discussions and author's closure, is published in *Transactions.*

17. *Digests.* Digests of 1,000 words (less 250 words for each figure) are required from the author for publication in *Electrical Engineering,* so that the membership-at-large may be apprised of at least the substance of all TP's. They should be submitted to Mr. Day with the manuscript.

Manuscript Guide for the Author of a Conference Paper

18. *Conference Papers.* Papers scheduled for a General Meeting or Special Technical Conference that were not offered for formal review; or, if reviewed, were not judged to have permanent reference value.

19. *Presentation.* A brief abstract or outline of the paper must be submitted for approval of the chairman of the sponsoring committee, 80 days or more before the meeting.

20. *Scheduling.* Scheduling the paper is at the sponsoring committee chairman's discretion. Conference papers on a certain subject may be solicited by him.

21. *Complete Manuscript.* Not required before the meeting, but if the author submits his paper *at least 65 days before the meeting,* in the same form as that required for Transactions papers, the Institute will reproduce it for preprint distribution.

22. *Distribution.* Distribution of conference papers by the author is permitted, provided at least 50 copies of his paper are furnished to the Institute to supply other requests.

A chart listing requirements for authors and publication rights for AIEE papers and articles will be found on the following page.

Requirements for Authors and Publication Rights for AIEE Papers and Articles

Paper Type	Preparation	Submission*	Review	Property of	Republishing
1. Transactions	Formal—single-spaced typing in accordance with p. 8, "Author's Guide"	Minimum of 90 days prior to presentation unless waived by Executive Committee	TOD	Institute	After presentation, by release from Publications Department of Institute giving full credit to AIEE
2. One-page Digest of Transactions Paper	Formal—double-spaced in accordance with p. 8, "Author's Guide"	To TOD when paper is submitted	TOD	Institute	ditto
3. Discussion	Formal—double-spaced typing in accordance with p. 8, "Author's Guide"	Within 2 weeks after presentation	Author of Transactions Paper	Institute	ditto
4. Conference (including District papers) (No preprint or own preprint)	Author's option	Abstract 2 weeks prior to day of presentation	Option of Technical Committee (Usually require an abstract only) (See: Submission)	Author	Institute name not mentioned. After presentation and provided it is not to be published by AIEE
5. Conference (Preprints by Institute)	Formal—single-spaced typing in accordance with p. 8, "Author's Guide"	Prior to submission date listed for that conference in the appropriate issue of *Electrical Engineering*	ditto	Author	ditto
6. Articles for *Electrical Engineering*	Formal—double-spaced typing in accordance with p. 8, "Author's Guide"	To Editor as early as possible	Publications Department	Institute	After publication, by release from Publications Department of Institute, giving full credit to AIEE

*General information on papers may be obtained from Assistant Secretary for Technical Papers.

General Restrictions on all Papers

1. Paper must not be released for outside publication prior to presentation.
2. No person shall receive monetary compensation from the reprinting of any paper or discussion presented before the Institute without previous authorization from the Board of Directors.

Nonlinear Magnetics and Magnetic Amplifiers Conference

THE 1958 Special Technical Conference on Nonlinear Magnetics and Magnetic Amplifiers will be held August 6-8, at the Statler Hotel, Los Angeles, Calif. It is being sponsored by the AIEE, with participation by the Instrument Society of America (ISA) and the Institute of Radio Engineers Professional Group on Industrial Electronics (PGIE of IRE).

The program of this third annual Conference will include sessions on applications, production methods, new horizons and analog techniques, and a complete session of papers of a tutorial nature. Also, there will be seminars devoted to theory and design, applications, and computer magnetics. It is expected that several papers will be presented by foreign authors.

Registration

Registration facilities will be open on August 5, Tuesday, 5:00 p.m. to 9:00 p.m. and Wednesday and Thursday from 9:00 a.m. to 4:30 p.m. The registration fee covers unlimited access to the technical sessions and the exhibits.

For further information and registration cards, please write Special Technical Conference, Box 2025, Downey, Calif.

Exhibits

Exhibits of the latest in magnetic components and systems will be featured. These will be of particular interest to those working in the fields of nonlinear magnetics and magnetic amplifiers. The exhibits will be located in the Statler's Golden State Room. The exhibits will be open August 6-8, from 10:00 a.m. to 9:00 p.m.

Ladies Program

Special emphasis has been placed on the ladies program. The wives of the Special Technical Conference Committee members will be on hand to greet, assist, and, generally, to make the stay of the ladies in Los Angeles an enjoyable experience.

During the registration period Tuesday, August 5 (12:00 p.m. to 6:00 p.m.), the Hospitality Room (Dallas Room) will be open for the benefit of the ladies. This room will be the social center and an information center to answer questions on Los Angeles and its many facilities. There will be a cocktail hour from 6:00 p.m. to 7:00 p.m. in the New York Room on a "pay as you go" basis, for the husbands as well as for the wives.

The program on Wednesday, August 6, will get under way at an 8:00 a.m. breakfast at the Statler. After breakfast, there will be available a chartered bus tour to Disneyland. The tour fee of approximately $7.50 will include round trip transportation, and a book of 10 tickets to the Disneyland rides.

Thursday, August 7, will be highlighted for the ladies by tour to the Hollywood-Beverly Hills area. This will include Hollywood, Beverly Hills, Malibu Beach Colony, Brown Derby Restaurant, Grauman's Chinese Theater, University of California at Los Angeles (UCLA), and Santa Monica Beach. Luncheon will take place at the world famous Hollywood Farmer's Market. The approximate cost of the tour will be $4.50.

Thursday evening will commence with a cocktail hour for husbands and wives at the Sierra Room from 6:00 to 7:00 p.m. followed by a banquet in the Pacific Ballroom of the Statler Hotel. The cost of the banquet will be $6.50 per person.

Friday, August 8, will be a time for independent trips. The wives of the committee members will be on hand to provide information and directions to tours, amusement points, clothing shops, restaurants, and to places of particular interest to the children.

Highlights

1. *Seminars.* This novel Conference feature will be conducted by three able moderators—Dr. H. Storm of the General Electric Company (GE), Dr. Alfred Krausz of Jack and Heintz, and Dr. J. A. Rajchman of the Radio Corporation of America (RCA). Questions, whether in the fields of theory and design, applications, or computer magnetics, will be discussed by leaders in magnetic "know-how." The committee cordially invites participation.

2. *Scholarship.* A special feature of the Conference will be a scholarship awarded in the name of the author of the outstanding conference paper to the university of his choice.

3. *Proceedings.* Many outstanding additional papers not presented at the Conference will be published in the Proceedings.

4. *Foreign Authors.* Authors from France, Switzerland, and the USSR have indicated a desire to present papers at this Conference. This will be an opportunity to gain an insight into European thinking on the subject of magnetics.

5. *Conference Speaker.* A banquet speaker, whose topic will be of interest to the ladies as well as the men, will be on hand to give an instructive and timely discussion.

Technical Program

The tentative technical program will be as follows:

Tuesday, August 5

Registration—Statler Hotel

Wednesday, August 6

Morning Session—Tutorial Group

Chairman: A. B. Haines, Bell Telephone Laboratories

Co-Chairman: H. F. Eckerle, Autonetics

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AIEE Order Department
33 West 39th Street,
New York 18, N.Y.

The Magnetization Process in Tape-Wound Cores. *R. C. Barker,* Yale University

Observation of Transients in the Series Connected Saturable Reactor with High Impedance Control Source. *H. L. Goldstein,* Bell Telephone Laboratories

Recommended Symbols for Magnetic Amplifier Papers. *H. F. Strom,* GE

Magnetic Amplifier Circuits—A Classification of Half-Wave and Full-Wave Nonreversible and Reversible Self-Saturating Circuits. *D. L. McMurtrie,* Raytheon

58-996 Magnetic Amplier Bibliography 1951-56. AIEE Magnetic Amplifier Applications Subcommittee

Afternoon Session—Application of Magnetic Amplifiers and Production Methods

Chairman: R. W. Roberts, Westinghouse Electric Corporation

Co-Chairman: R. C. Byloff, AiResearch

Influence of Excitation Frequency and Waveform on Squareness Ratio of Toroidal Tape Cores. *J. E. Wolf,* Arnold Engineering Co.

The Application of Magnetic Amplifiers to Electronic Timers. *S. W. Brown,* Autonetics

Comparative Study of Push-Pull Magnetic Amplifiers. *A. H. Meiksin,* Westinghouse Electric Corporation

Effects of Environment on Magnetic Properties of Toroidal Cores. *J. E. Mitch, Art Lewis,* Arnold Engineering Co.

Evening Session—Seminars

"Theory and Design." Discussion lead by H. F. Storm, GE

"Applications." Discussion lead by A. Krausz, Jack and Heintz

"Computer Magnetics." Discussion lead by J. A. Rajchman, RCA

Thursday, August 7

Morning Session—Computer Magnetics

Chairman: C. T. Leondes, UCLA

The State of the Art. *J. A. Rajchman,* RCA

All-Transistor Magnetic Core Memory. *B. T. Goda, W. R. Johnson, M. Rosenberg, Seymour Markowitz, Raymond Stewart-Williams,* Telemeter Magnetics, Inc.

The Twistor—Its Use in a Memory Array. *A. H. Bobeck, R. S. Title,* Bell Telephone Laboratories

A Diodeless Magnetic Core and Capacitor Logical Circuit. *M. Dumaire, H. Jeudon, M. Lilamand, J. Brodin,* Societe d'Electronique, France

AIEE Future Meetings

AIEE-IRE-ISA Nonlinear Magnetics and Magnetic Amplifiers Conference (Exhibit)*
Statler Hotel
Los Angeles, Calif.
August 6-8, 1958

AIEE-IRE-NBS Electrical and Radio Standards Conference*
University of Colorado and NBS
(Dormitory Accommodations)
Boulder, Colo.
August 13-15, 1958

Pacific General Meeting*
Hotel Senator
Sacramento, Calif.
August 19-22, 1958

AIEE-NEMA National Electrical Insulation Conference*
Pick-Carter Hotel
Cleveland, Ohio
September 3-5, 1958

Fifth UPADI Convention
Queen Elizabeth Hotel
Montreal, Que., Canada
September 2-6, 1958

World Power Conference Sectional Meeting
Queen Elizabeth Hotel
Montreal, Que., Canada
September 7-11, 1958

Petroleum Industry Conference*
Baker Hotel
Dallas, Texas
September 15-17, 1958

Power Industry Computer Application Conference*
King Edward Hotel
Toronto, Ont., Canada
September 15-17, 1958

AIEE-IRE Industrial Electronics Conference*
Park Shelton Hotel
Rackham Memorial Auditorium
Detroit, Mich.
September 24-25, 1958

AIEE-ASME National Power Conference*
Statler Hotel
Boston, Mass.
September 29-October 1, 1958

AIEE-IRE-EIA-SMPTE National Electronics Conference
Hotel Sherman
Chicago, Ill.
October 13-15, 1958
(Final date for †TP—Closed, ‡CP Syn.—closed, CPMs—Aug. 8)

Machine Tools Conference
Statler Hotel
Hartford, Conn.
October 13-15, 1958
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Aug. 8)

Farm Electrification Conference
Monteleone Hotel
New Orleans, La.
October 20-22, 1958
(Final date for †TP—closed, ‡CP Syn.—Aug. 5, CPMs—Aug. 15)

Fall General Meeting
Penn-Sheraton Hotel
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—closed, ‡CP Syn.—Aug. 12, CPMs—Aug. 22)

Fall Textile Conference
North Carolina State College
Raleigh, N. C.
October 30-31, 1958
(Final date for †TP—Aug. 1, ‡CP Syn.—Aug. 15, CPMs—Aug. 26)

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference
Pick-Nicolett Hotel
Minneapolis, Minn.
November 19-21, 1958
(Final date for †TP—Aug. 21, ‡CP Syn.—Sept 5, CPMs—Sept. 15)

Magnetism and Magnetic Materials Conference
Sheraton Hotel
Philadelphia, Pa.
November 17-20, 1958
(Final date for †TP—Aug. 19, ‡CP Syn.—Sept. 3, CPMs—Sept. 12)

AIEE-IRE-ACM Eastern Joint Computer Conference (Exhibit)
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958
(Final date for †TP—Sept. 4, ‡CP Syn.—Sept. 19, CPMs—Sept. 29)

AIEE-IRE Second National Symposium on Communication Systems (Exhibit)
Colonial Inn-Desert Ranch
St. Petersburg, Fla.
December 3-5, 1958
(Final date for abstracts and summaries—Aug. 1)

AIEE-IRE-ASQC-EIA National Symposium on Reliability and Quality Control
Bellevue-Stratford Hotel
Philadelphia, Pa.
January 12-14, 1959
(Final date for †TP—Oct. 14, ‡CP Syn.—Oct. 29, CPMs—Nov. 7)

Winter General Meeting
Statler Hotel
New York, N. Y.
February 1-6, 1959
(Final date for †TP—Nov. 3, ‡CP Syn.—Nov. 18, CPMs—Nov. 28)

AIEE-IRE-U of P Transistor and Solid-State Circuits Conference
University of Pennsylvania
Philadelphia, Pa.
February 12-13, 1959
(Final date for †TP—Nov. 13, ‡CP Syn.—Nov. 28, CPMs—Dec. 9)

EJC Nuclear Congress
Cleveland, Ohio
April 5-10, 1959
(Final date for †TP—Nov. 28)

South East-South Central District Meeting
Dinkler Plaza Hotel
Atlanta, Ga.
April 8-10, 1959
(Final date for †TP—Jan. 8, DPMs—Feb. 2)

East Central District Meeting
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, DPMs—Feb. 16)

Rubber and Plastics Conference
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, ‡CP Syn.—Feb. 6, CPMs—Feb. 16)

Empire District Meeting
Hotel Syracuse
Syracuse, N. Y.
April 29-May 1, 1959
(Final date for †TP—Jan. 29, DPMs—Feb. 20)

AIEE-IRE-EIA-WCEMA Joint Electronic Components Conference
Benjamin Franklin Hotel
Philadelphia, Pa.
May 6-8, 1959
(Final date for †TP—Feb. 5, ‡CP Syn.—Feb. 20, CPMs—March 2)

Middle Eastern District Meeting
Lord Baltimore Hotel
Baltimore, Md.
May 19-21, 1959
(Final date for †TP—Feb. 18, DPMs—March 13)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Authors Guide*. For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N.Y.

Afternoon Session—Application of Nonlinear Magnetics

Chairman: H. C. Bourne, UCLA
Co-Chairman: A. Krausz, Jack and Heintz

An Equivalent Circuit for Transformers in which Nonlinear Effects Are Present. *H. W. Lord*, GE

Variation of Pulse Width in Magnetic Pulse Generators. *B. M. Wolfframm*, Magnetic Research Corp.

An Analysis of the Operation of the Magnetic Second Harmonic Modulator. *B. W. Jalbert*, GE

Equivalent Circuit Approach to the Analysis and Design of Magnetic Frequency Triplers. *C. R. Slemon, P. O. Biringer*, University of Toronto

A More Stable Three-Phase Transistor-Core Power Inverter. *P. L. Schmidt, W. E. Jewett*, Bell Telephone Laboratories

Evening—Banquet

Friday, August 8

Morning Session—New Horizons

Chairman: A. B. Rosenstein, UCLA
Co-Chairman: C. B. Wakeman, Magnetics, Inc.

The Use of Magnetic Amplifiers at High Frequencies. *R. E. Jackson*, Alwac Corporation

A Bridge Type High Gain Magnetic Amplifier for Use at High Temperatures. *S. D. Warner*, Convair

Theory and Operation of Two Crossfield Magnetic Modulators. *D. W. Boensel*, Jet Propulsion Laboratory

Shunt-Coupled Magnetic Amplifier Circuits. *R. W. Hubbard*, Boeing Aircraft

Analog Division Circuits. *William McMurray*, GE

High Frequency Temperature Stable Magnetic Amplifier. *C. K. Leonard*, GE

Afternoon Session—Computer Magnetics II

Chairman: J. A. Rajchman, RCA
Co-Chairman: G. Estrin, UCLA

Magnetic Networks for Performing Logic. *P. F. Gianola, T. H. Crowley*, Bell Telephone Laboratories

Ferroresonant Switching Circuits. *W. E. Proebster*, IBM Research Laboratories, Zurich, Switzerland

Thin Film Magnetization Studies. *R. L. Conger*, U. S. Naval Ordnance Laboratories

Magnetic Integrating Amplifiers. *H. W. Patton*, Acromag, Inc.

Hotel Reservations

The Statler Hotel, which will be the scene of the technical sessions, as well as the exhibits, has set aside ample rooms for the accommodation of Conference registrants.

Price lists for the accommodations available are as follows:

Singles	$ 8.00	$12.00
	9.00	13.00
	10.00	14.00
	11.00	
Doubles	$11.50	$14.50
	12.50	15.50
	13.50	16.50
Doubles, twin beds	$12.00	$16.00
	13.00	17.00
	14.00	18.00
	15.00	
Suites, one person	$22.00 to $28.00	
Suites, two persons, double bed	$22.00 to $34.00	
Suites, two persons, twin beds	$22.00 to $36.00	

For each additional person over two in room the charge daily is $2.50 extra.

In the event that accommodations of the type and price desired are not available, the next best reservation will be confirmed by the Statler.

There is no requirement that Conference members stay at the Statler. Those wishing to do so may communicate directly with the hotel of their choice.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Engineering Foundation Grants Advance 26 Projects

The continuation of studies that are steadily reducing the cost of reinforced concrete construction; another study that will eliminate uncertainties in the properties of high-temperature and high-pressure steam for power generation, whether from coal, oil, or atomic heat; still another aimed at reducing our huge annual losses from metallic corrosion—these are just a few of the important research projects that are receiving Engineering Foundation support.

At a meeting held in New York, N. Y., on May 16, 1958, Engineering Foundation announced grants of $71,500 to advance research in the 1958-59 fiscal year. These new allocations will further 26 projects that will also receive nearly $1 million outside support from industry. The projects, to which funds have been allocated, represent all the important branches of the engineering profession. They are being carried out in university, Government, and industrial laboratories all over the country under sponsorship of the major engineering societies.

Report of the AIEE Board of Directors*
May 1, 1957-April 30, 1958

FOUR MEETINGS of the AIEE Board of Directors were held in the following cities: Montreal, Que., Canada; Chicago, Ill.; New York, N.Y.; and Washington, D.C. Information regarding the more important decisions made by the Board were reported in various issues of *Electrical Engineering*.

The usual four General Meetings of the Institute were held: Summer, Montreal, Que., Canada; Pacific, Pasco, Wash.; Fall, Chicago, Ill.; and Winter, New York, N.Y.

Four District Meetings were held: North Eastern, Pittsfield, Mass.; Middle Eastern and East Central, Dayton, Ohio; South West, Tulsa, Okla.; and Middle Eastern, Washington, D.C.

The Institute wholly or partly sponsored 27 special technical conferences during the year and the total attendance at all meetings and conferences was 38,106, a total of 2,159 papers being presented.

Constitution and Bylaws Committee

This Committee concentrated on a revision of the Institute's Constitution and Bylaws. Two preliminary drafts have been approved by the Board of Directors and the final draft was to be submitted to the Board at its meeting on June 27, 1958. This revised Constitution when approved will be voted on by the membership at a later date. The new Bylaws, which need only the approval of the Board of Directors, will be submitted during the coming year.

There are many rules, regulations, and procedures of the Institute, which appear in many different publications of Departments and committees. It is proposed to collect all these data, and publish a new set of regulations to be known as "Rules." These will be completed during 1958-59.

During the year, the Certificate of Incorporation was changed, as was also the number of Directors from 21 to not less than 20 nor more than 40.

Finance Committee

The finances of the Institute are in a healthy state. The dynamics of the market have been such, recently, that the portfolio of holdings was adjusted to maintain earnings consistent with the security and marketability required.

A recommendation from the Trustees of the AIEE Retirement System was considered and revised, bringing the system up

*This is a summary of the Report of the Board of Directors. Anyone wishing a copy of the complete report should write to: The Secretary, AIEE, 33 W. 39th St., New York 18, N. Y. Copies of the complete report have been mailed to the chairmen of all general and technical committees of the Institute.

to modern practices in recognition of the changes in the economy and expansion of Social Security.

The Board approved an amendment to Bylaw 20 to provide a more definitive cut-off on the publications mailing for members in arrears, thus simplifying control of membership records.

For the Institute's balance sheet and the statement of income and operating fund reserve for the fiscal year ending April 30, 1958, see Exhibits A and B at the end of this summary.

Planning and Co-ordination Committee

The work of this Committee has been directed along the following lines: a schedule of Director's meetings; amendment of Constitution and Bylaws; assignment of intersociety representatives; bylaws of medal committees; and organizational changes in the Institute.

Public Relations Committee

This Committee, operating under the Administration Department, has produced a number of tools to attract young people into the profession of electrical engineering and to acquire new AIEE members. Among these was a new booklet, "The Indispensable Man—the Electrical Engineer"; a radio script, "Your Child's Future —Consider Electrical Engineering," which was widely broadcast by many stations; a syndicated newspaper mat, "Electrically Speaking," which was distributed to 2,000 daily and weekly newspapers and used extensively.

The Committee co-operated with local meeting and conference committees to help them publicize these events and also worked with the several Sections to help them with their public relations problems.

Sections Committee

During the year, two new Sections were recognized, bringing the total to 112; two new Subsections brought that total to 67; and the technical groups now number 223, an increase of 76 from 1957.

The total number of meetings has increased from 2,315 in 1957 to 2,606 in 1958 and the total attendance at these meetings broke another record with 137,373, more than 7,000 over the year before.

Student Branches Committee

Student membership in AIEE increased to 10,592 as of May 1, 1958, an increase of 8.7% over last year. During the fiscal year, the Board of Directors approved the establishment of two Associate Branches and two Affiliate Branches. There are now 157 Branches, which held 1,374 meetings during the year with a total attendance of 87,477.

Admission and Advancement Department

During the past year, a list of foreign universities was compiled, graduates of which represent the majority of applicants for AIEE membership, to determine if these schools' academic standards are the equivalent of Engineers' Council for Professional Development (ECPD) accredited colleges in the United States.

At the 1957 Summer General Meeting, the Board authorized rebate of entrance and transfer fees to the originating Sections for a period of a year.

Board of Examiners

In the period 1957-58, the Board acted upon 11,016 applications for membership or transfer from one grade to another, an increase of 13% over the previous year.

Membership Committee

Total membership of the Institute as of April 30, 1958, is 52,213, an increase of 1,655 members (3.3%) as compared with an increase of 609 last year. New members increased 11.8% and former members reinstated increased 8.9% over last year.

Medals and Awards

The following Institute medals and awards were made during 1957-58:

Edison Medal to J. K. Hodnette, Westinghouse Electric Corporation.

Lamme Medal to Dr. H. S. Black, Bell Telephone Laboratories.

AIEE Medal in Electrical Engineering Education to Dean W. L. Everitt, University of Illinois.

Charles LeGeyt Fortescue Award to T. J. Harley, Jr., University of Pennsylvania.

John Fritz Medal to J. R. Suman, Standard Oil of New Jersey.

Elmer A. Sperry Award to H. L. Hamilton, R. M. Dilworth, and E. W. Kettering, General Motors Corp.

Washington Award to Adm. Ben Moreell, Jones & Laughlin Steel Corp.

Recognition Awards Committee

This new Committee will administer the two new awards: The Morris E. Leeds Award, consisting of $500 and a certificate for achievement in the field of electric instrumentation; and the William M. Habirshaw Award, consisting of a bronze medal and $500 for achievement in the field of transmission and distribution. These will be presented for the first time at the AIEE Fall General Meeting in Chicago, Ill., in 1959 along with the fourth medal in Electrical Engineering Education.

Publications Department

Electrical Engineering. The editorial content of the monthly magazine has been selected in accordance with the primary interest of the membership in accordance with the surveys of 1951 to 1956. Each month, 1,000 questionnaires are mailed to members in proportion to the number in each state with the request that they indicate their preferences for the articles and departments of the magazine.

A change to rotary press (web) printing with the January 1957 issue reduced the printing costs of *Electrical Engineering* more than $60,000, but, because of increased prices and expanded volume, the total costs have increased by more than $45,000.

At the close of the calendar year 1957 compared with the one previous, the magazine had an increase of 103 pages of product advertising with a gross billing increase of $87,000. However, at the close of the fiscal year, April 30, 1958, it is estimated that the net advertising income will be $20,000 less than at the close of the previous fiscal year; a result of the business recession.

Bimonthly Publications. The average editions of these three publications have increased 19.4% over the previous year. The total number of pages produced was 2,836 for a decrease of 5.9% under the pages produced during the previous year.

Transactions. Volume 76 will be issued in three parts containing a total of 407 papers, in 2,836 pages.

Special Publications. Nine publications were produced during the year with a total of 1,012 pages. Four originated from Special Technical Conferences and five from the General Meetings and special projects of technical committees.

Technical Operations Department

The Technical Operations Department (TOD) established a five-man Administrative Committee and seven standing Subcommittees each headed by a TOD member. The accomplishments of these Subcommittees are as follows:

1. *TOD Manual.* The section on "Processing of Papers" was approved and distributed as was a "One-Page Author's Guide." Some 15 other sections are in progress.

2. *Special Technical Conferences.* A broad study and analysis of this subject is under way leading to enactment of policy, rules, and procedures.

3. *Classification of Engineers.* By collecting classified past lists of engineers and exploring the matter with Engineers Joint Council (EJC) and the National Register of Scientific and Technical Personnel, this Subcommittee is prepared to comply with future requests.

4. *Technical Groups in Sections.* This Subcommittee has appointed alternates for each District TOD representative to insure continuity; developed a standard information sheet for recommending new technical-committee members; arranged to have preprinted District papers reviewed like preprinted Conference papers; and encouraged study groups and educational programs.

5. *Exhibits.* Since the Board of Directors' approval of exhibits at any AIEE meeting, uniform procedures and regulations are now being developed.

6. *Forecasts and Statistics.* Regular forecasts of numbers of sessions and papers for all General and District Meetings are made two years ahead each September and February.

7. *5-Year Advance Meeting Schedule.* The latest one appeared in the June 1958 issue of *Electrical Engineering*, p. 521. An attempt is being made to develop a preferred pattern for District Meetings to even out the Headquarter's load.

Five other committees under TOD have been established, their titles being descriptive of their scope: Man–Machine Integration, Grouping of Committees, Standing Program Committee for EJC Nuclear

Congress, Joint Division Committee on Automation and Data Processing, and Publication Policies of Other Societies.

Research Committee

This Committee held a two-day conference in Ottawa before the Fall General Meeting in Chicago to explore the methods for increasing the research activities of the Institute through the Engineering Foundation.

Safety Committee

The medical consultants of the Committee have introduced new concepts of resuscitation, primarily the mouth-to-mouth method. In order to obtain contacts with other groups in the Institute, a Liaison Representatives Subcommittee has been set up to promote consideration of the safety aspects of each project or activity in the technical area.

Noting that there was a difference in wording format but not in intent between the National Electrical Code and the Canadian Electrical Code, the Committee initiated an activity to bring these two documents together as there are no significant differences between the codes of the two countries.

Standards Committee

A revision of the Standards Manual is being undertaken, with the thought that it will be a more useful guide to technical committees concerned with the preparation and revision of Standards. The Committee approved 21 publications during the last year.

Technical Committees

The Report contains detailed reports from 48 of the Institute's technical committees, concerning their activities for 1957-58.

Representatives

The Report includes reports on the year's activities from the following: EJC, ECPD, International Illumination Commission, United Engineering Trustees, U.S. National Committee of the International Electrotechnical Commission, and U.S. National Committee of the World Power Conference.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Exhibit A — **Balance Sheet, April 30, 1958**

ASSETS

Property Fund Assets:		
Founder Society advances to United Engineering Trustees, Inc. (not repayable except upon latter's dissolution; 4% interest payable from date of occupancy of United Engineering Center)—see note	$265,000	
Other properties at nominal values (library, works of art, etc.)	16	
TOTAL PROPERTY FUND ASSETS		$ 265,016
Restricted Fund Assets:		
Investments:		
Securities (market value $1,151,720)	$835,288	
4½% note of United Engineering Trustees, Inc.	340,000	
Cash	18,593	
Accrued interest purchased	92	
TOTAL RESTRICTED FUND ASSETS		1,193,973
Operating Fund Assets:		
Cash	$ 84,791	
Accounts receivable:		
Members—for dues	46,016	
Advertisers	5,740	
Technical conference loans	9,597	
Subscriptions, etc. (less reserve, $3,000)	44,962	
Inventories—at cost or less:		
Transactions	19,639	
Text and cover paper	35,335	
Badges	4,577	
Production charges for May and subsequent issues of *Electrical Engineering*	18,850	
Prepaid expenses	4,743	
Office equipment, furniture, and fixtures (less reserve for depreciation, $71,808)	40,156	
TOTAL OPERATING FUND ASSETS		314,406
TOTAL		$1,773,395

LIABILITIES

Property Fund Reserve:		
Founder Society advances to United Engineering Trustees, Inc.—see note	$ 265,000	
Other	16	
TOTAL PROPERTY FUND RESERVE		$ 265,016
Restricted Fund Reserves (Exhibit C):		
Reserve capital fund	$1,113,154	
Members-for-Life fund	29,748	
International Electrical Congress of St. Louis Library fund	6,611	
Edison Medal fund	10,819	
Edison Endowment fund	7,986	
Lamme Medal fund	9,700	
Mailloux fund	1,051	
Volta Memorial fund	12,663	
Kettering Award fund	2,241	
TOTAL RESTRICTED FUND RESERVES		1,193,973
Operating Fund Reserve, Liabilities, Etc.:		
Accounts payable	$ 68,283	
Accrued expenses	28,098	
Deferred income, etc.:		
Dues	67,546	
Subscriptions to publications, etc.	58,206	
Other	6,960	
Operating fund reserve (Exhibit B)	85,313	
TOTAL OPERATING FUND RESERVE, LIABILITIES, ETC.		314,406
TOTAL		$1,773,395

NOTE: By agreements dated February 28, 1958, the Founders' Agreement of August 10, 1916, between the four Founder Societies, parties thereto, and United Engineering Trustees, Inc., was superseded by an amended Founders' Agreement which, among other things, provided: for the admission of a fifth Founder Society; for commitments by each of the five Societies to permanently maintain their respective principal offices in the United Engineering Center Building to be erected at United Nations Plaza; for recognition of advances paid to United Engineering Trustees, Inc., namely $265,000 by each of the four Societies pursuant to the superseded Founders' Agreement of 1916, and $50,000 by the fifth Society; and that none of said advances were to be repayable by United Engineering Trustees, Inc., except upon its dissolution but that each advance was to bear interest at 4% from the dates of occupancy of United Engineering Center by each of the respective Societies.

Pursuant to the foregoing, the Institute has reduced the book value of its Founder's interest in United Engineering Trustees, Inc., from $498,448, being one fourth of the book value of the latter's West 38th Street property funds, to the amount of its stipulated advance of $265,000 as aforesaid.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Exhibit B — **Statement of Income and Operating Fund Reserve for the Year Ended April 30, 1958**

Income:		
Dues:		
Members	$842,927	
Students	42,638	$ 885,565
Fees:		
Entrance	$ 20,744	
Transfer	5,325	26,069
Publications sales:		
Advertising	$511,211	
Electrical Engineering subscriptions, etc.	42,607	
Transactions volumes	33,469	
Bimonthlies subscriptions etc.	27,912	
Preprints, special and technical publications, etc.	82,833	698,032
Other income:		
Meetings registration fees	$ 50,675	
Technical conferences—net	22,771	
Income from Reserve Capital Fund investments:		
Marketable securities	40,332	
Note of United Engineering Trustees, Inc.	10,540	
Standards sales (including binders)	23,930	
Sale of member emblems	676	
Miscellaneous	1,286	150,210
TOTAL INCOME		$1,759,876
Expenses:		
Administration Department:		
Public Relations	$ 38,269	
Sections	153,132	
Student Branches	38,654	
Other	23,610	$ 253,665
Admission and Advancement Department—Membership		15,642
Professional Development and Recognition Department		8,335
Technical Operations Department:		
Institute Meetings	$ 68,028	
Technical Activities	28,914	
Standards Committee	37,906	
Other	4,795	139,643
Forward		$ 417,285

TOTAL INCOME (Forward)		$1,759,876
Expenses (Forward)		$ 417,285
Publications Department:		
Electrical Engineering:		
Advertising	$279,041	
Text	203,733	
Transactions volumes	42,965	
Bimonthlies	165,752	
Membership directory and organization manual	26,639	
Preprints, special and technical publications, etc.	108,446	826,576
Institute Districts		6,085
Constitution and Bylaws Committee		421
Finance Committee		1,924
Planning and Coordination Committee		155
General and Administrative:		
Salaries	$225,586	
Postage	7,947	
Stationery and supplies	17,684	
Contributions under retirement plan (not including $19,749 paid from Reserve Capital Fund for additional past service benefits)	22,098	
Social security taxes	7,757	
Legal fees	550	
Travel expenses of Directors and President	16,415	
Depreciation of equipment, etc. (including accelerated depreciation of furniture and fixtures $7,029.75)	13,486	
United Engineering Trustees, Inc.:		
Building assessments (exclusive of $10,507 charged to other accounts)	35,269	
Library assessments	19,920	
Library pension	7,287	
Rental of equipment	4,772	
Conversion costs to punched cards	11,574	
Provision for doubtful accounts	3,000	
Other	28,772	422,117
TOTAL EXPENSES		$1,674,563
Excess of Income Over Expenses for the Year		$ 85,313
Operating Fund Reserve, May 1, 1957		198,387
TOTAL		$ 283,700
Transfer to Reserve Capital Fund (Exhibit C)		198,387
Operating Fund Reserve, April 30, 1958		$ 85,313

HASKINS & SELLS
CERTIFIED PUBLIC ACCOUNTANTS

67 BROAD STREET
NEW YORK 4

May 28, 1958

ACCOUNTANTS' CERTIFICATE

American Institute of Electrical Engineers:

We have examined the balance sheet of the American Institute of Electrical Engineers as of April 30, 1958, and the related statements of income and operating fund reserve and of restricted fund reserves for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet and statements of income and operating fund reserve and of restricted fund reserves present fairly the financial position of the Institute at April 30, 1958, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied (except for the change explained in the note to the balance sheet) on a basis consistent with that of the preceding year.

(*signed*) HASKINS & SELLS

Sample Contents Lists from USSR Scientific and Engineering Journals

THE FOLLOWING are sample contents lists from some of the leading Soviet scientific and engineering journals, translations of which are being made available by arrangement with the Pergamon Institute, a nonprofit organization.

For a listing and prices of the publications, available on an annual subscription basis, and ordering instructions, see p. 59A of this issue of *Electrical Engineering*.

Radio Engineering and Electronics USSR, No. 1, 1958.

Contents

Zheleznov, N. A. Principle of discretisation of stochastic signals with unlimited spectrum and some results of the theory of pulse transmission of information.
Shastova, G. A. Interference resistivity of Hamming code.
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Yavich, L. R. Questions of broadband discharger design.
Gvosdover, S. D. et al. Experimental study of mutual-synchronous operation of X-band reflex klystrons.
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Mirimanov, R. G.; Lomze, L. G. Some titanate ferrites at microwave frequencies.
Aksenov, V. I. Determination of losses of ferromagnetic material at microwave frequencies.

Radio Engineering and Electronics USSR, No. 2, 1958.

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Trenev, N. G. Diffraction of surface electromagnetic waves on a semi-infinite impedance plane.
Braude, S. G. et al. The statistic nature of scattering of centimeter waves on a disturbed sea surface.
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Kurochkin, S. S. The theory of a spin generator.
Zanadvorov, P. N. Synchronization of an oscillator by periodic pulse train.
Andreev, V. S. Investigation of stationary operation of a regenerative frequency divider.
Bakaev, G. N. Investigation of television synchronization flywheel system.
Borovitsky, S. I. Some properties of optical converters in radio engineering.
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Rapoport, G. N. Preliminary results of nonlinear theory of oscillations in a backward wave tube with longitudinal field.
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Der-Schwarz, G. V. Grid integrators of increased accuracy for the field calculation of electron optical systems.
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Miscellany

Zhabotinsky, M. E. et al. The crystal oscillator frequency dependence upon the power being dissipated in quartz.
Martinenko, D. P. Overtone synchronization of auto-oscillations with an external amplitude-modulated force.
Achmanov, S. A. et al. Amplitude of fluctuations of two mutually-synchronized reflex clystrons.
Seman, O. I. Normal coefficients of electron optical aberrations of magnetic immersion systems.
Berstein, I. L. The theory of phase automatic frequency trim.
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Sindler, J. B. The question of noise storing in radio-links.
Aralov, M. S. The properties of a pentode with negative potential on the third grid.

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Radio Engineering and Electronics USSR, No. 3, 1958.

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Melnikov et al. Pressed cathode basis of $BaWO_3$-$CaWO_3$.
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Butkevitch et al. Some investigations of secondary electron emission on the exit side.
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Miscellany

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Electric Technology USSR, No. 3, 1958.

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Gelbukh, L. A. Heating of a ferromagnetic ellipsoid in an alternating magnetic field.
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Greisukh, M. V. How to establish correctly the prices for electrical equipment and construction work.
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Guba, K. F. The frequency of a Rochelle salt piezo-vibrator as a function of temperature.
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Discussion

In other Engineering Journals

Chronicle

Bibliography

AIEE Fort Wayne Section

It has been announced that the date of October 9, 1958, has been selected for the 50th Anniversary Celebration of the Fort Wayne Section of the Institute.

Canadian Sectional Meeting of the World Power Conference

One of the largest international gatherings of its kind ever held will open in Montreal, Que., Canada, on September 7.

The occasion is the technical session of the World Power Conference, meeting in Canada for the first time in its history and expected to attract more than 1,000 scientists, engineers, economists, and other experts from some 50 different countries.

The meeting will be held at The Queen Elizabeth, Canada's newest and largest hotel, September 7-11, 1958. Proceedings will be conducted in English and French, by means of simultaneous translation facilities set up especially for the event.

In addition to participation in the technical session in Montreal, many of the delegates plan to accompany study tours which have been organized to visit important hydro, thermal, and atomic energy plants.

Founded in Great Britain in 1924, the World Power Conference is an international nongovermental agency which forms a continuing link between the different branches of power and fuel technology, between experts of the nations of the world, and between scientists and engineers on the one hand and economists and administrators on the other. Some 52 countries have membership and maintain national committees within the organization, and additional countries participate in the technical meetings.

Since the first World Power Conference, held in Great Britain in 1924, 14 plenary and sectional meetings have been held, the most recent in Belgrade, Yugoslavia, in 1957. Only once before has the Conference met in North America, and that was 22 years ago, in Washington, D.C.

Theme of the Canadian sectional meeting, according to Major General H. A. Young, Canada's deputy minister of public works and chairman of the Canadian Committee, will be "Economic Trends in the Production, Transportation, and Utilization of Fuel and Energy." Some 150 technical papers are being presented under these three main divisions. Discussion of the papers will be in English and French, the two official languages chosen for the meeting.

Under the 'production' section of the Conference, delegates will examine trends in the production of hydraulic energy, of thermal energy, including coal, oil, and nuclear, and of other forms of energy. Economic trends in the transportation of fuel and energy by electric transmission, rail, water, pipeline, and other means will be studied under Division II. Finally, the economic trend in the use of power in business and industry, in transportation, on the farm, and in the home, will be discussed under the utilization division.

Post-Conference tours will include visits to many points of interest. One of these will enable delegates to study the St. Lawrence Seaway and Power Project, power development at Niagra Falls, and an atomic reactor at Shippingport, Pa. In others, hydroelectric developments at Beauharnois and on Quebec's Saguenay, Peribonka, Bersimis, and St. Maurice Rivers will be visited. Arrangements have been made for an inspection of the Richard L. Hearn thermal plant in Toronto as well as of a hydraulic laboratory at Islington, Ontario.

Hugh Crombie, vice-president of Dominion Engineering Works Ltd., is general chairman of the various subcommittees involved in making arrangements for the Canadian meeting. General Secretary is T. M. Patterson, director of the Water Resources Branch of Canada's Department of Northern Affairs and National Resources.

Chairmen of the subcommittees include: J. A. Fuller, president, Shawinigan Water & Power Co.; R. Latreille, commissioner, Quebec Hydro-Electric Commission; A. C. Abbott, vice-president, Shawinigan Water & Power Co.; R. L. Hearn, consulting engineer; B. C. Fairchild, managing director, Canadian Electrical Association; M. P. Murphy, executive vice-president, Northern Electric Co.; R. L. Dunsmore, president, Champlain Oil Products Ltd.; Alan Field, director, Canadian Government Travel Bureau; L. A. Wright, general secretary, The Engineering Institute of Canada; A. W. Manby, general manager, The Hydro-Electric Power Commission of Ontario; and Louis O'Sullivan, commissioner, Quebec Hydro-Electric Commission.

"Research—Gateway to the Future" Will Be Theme of Fall General Meeting

THE 1958 Fall General Meeting of the AIEE will be held in Pittsburgh, Pa., October 26-31. Headquarters for the meeting will be the Penn-Sheraton Hotel which is located across from new Mellon Square Park, in the heart of the Golden Triangle.

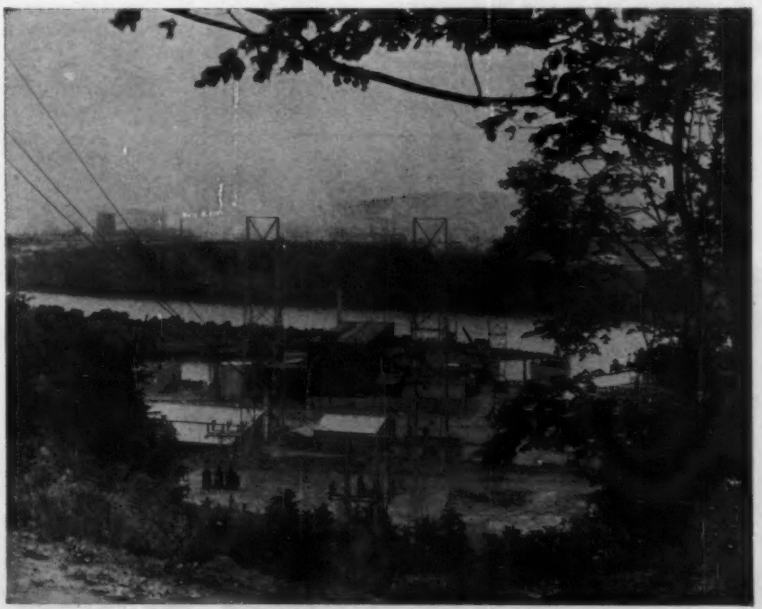
On Thanksgiving Day of 1958, Pittsburgh will begin a year long celebration of its Bicentennial as the "Gateway to the Future." It is appropriate, therefore, that the Local Arrangements Committee has selected as the theme for the Fall Meeting "Research—Gateway to the Future."

Inspection Trips

Plans have been made to visit the research centers of the Aluminum Company of America, United States Steel, and Westinghouse Electric Corporation. Under the auspices of the Union Switch and Signal Co., an inspection trip will be made to Conway, Pa., where the Pennsylvania Railroad operates one of the world's largest automatic classification yards. There will also be trips to the United States Steel Irvin Works, and to the Westinghouse Atomic Reactor Valuation Center and Atomic Power Division. A highlight of the inspection trip program will be a visit to the Shippingport Atomic Power Station which is operated by the Duquesne Light Company of Pittsburgh.

Ladies Activities

The Ladies Activity Committee, headed by Mrs. Tomlinson Fort, is arranging an



AN INSPECTION TRIP of the Shippingport Atomic Power Station of the Duquesne Light Company will be made on Wednesday, October 29, in connection with the AIEE Fall General Meeting. This is the world's first full scale electric power plant devoted exclusively to peacetime needs utilizing an atomic reactor as its primary heat source.

interesting program for the ladies who attend the Fall Meeting. Among the events scheduled are a luncheon at the Longue Vue Country Club, a dessert-bridge at the Duquesne Light Company's Utility Hall, and a visit to the Nationality Rooms at the University of Pittsburgh. The Presidential Suite in the Penn-Sheraton Hotel will serve as the headquarters for the ladies throughout the week.

Committees

The members of the Fall General Meeting Committee are: A. A. Johnson, chairman; Dixon Lewis, vice-chairman; W. H. Osterle, secretary; A. P. Hayward, treasurer; Pascal Beckjord, hospitality; C. N. Clark, hotels, meeting rooms, and facilities; Mrs. Tomlinson Fort, ladies activities; M. P. Getting, registration; E. L. Harder, program; W. R. Harris, chairman Pittsburgh Section; E. M. Hays, inspection trips and transportation; R. E. Larson, papers, printing, and tickets; E. S. Reeser, entertainment; F. H. Schlough, publicity; B. R. Teare, Jr., vice-president, District No. 2; and E. M. Williams, student activities.

Conference on Electronic Standards and Measurements

The AIEE Electronic and High-Frequency Instruments Committee, under the Chairmanship of Ferdinand Hamburger, Jr., is serving as cosponsor of a Conference of national scope to be held in Boulder, Colo., on August 13-15, 1958. Other cosponsors will include the Professional Group on Instrumentation of the Institute of Radio Engineers (IRE), and the Radio Standards Laboratory of the National Bureau of Standards (NBS). The Conference will be held immediately prior to the IRE's WESCON in Los Angeles, Calif., which begins August 19.

Registration fee is $5. The second and detailed announcement for the Conference was distributed through a large mailing in June. If you did not receive a copy (including registration form), it may be obtained by writing to: J. F. Brockman, NBS Boulder Laboratories, Boulder, Colo.

Since the Conference is being held during the popular tourist season, it is very advisable to register and make housing reservations well in advance.

The Conference will be held in an area of great scenic beauty. The social events and sightseeing trips will appeal to the entire family.

The tentative technical program for the Conference follows.

Wednesday, August 13

1:30 p.m. Session 1

Opening Address: A. V. Astin, director, NBS, Washington, D.C.

Introduced by Conference Chairman, B. M. Oliver, Hewlett-Packard Co.

"The Relationship of Standards to Physical Constants"
Chairman, J. M. Richardson, NBS Boulder Laboratories

Standards and Physical Constants. *R. D. Huntoon,* NBS, Washington, D.C.

Present Status of Precise Information on the Universal Physical Constants. Has the Time Arrived for Their Adoption to Replace Our Present Arbitrary Conventional Standards? *J. W. M. DuMond,* California Institute of Technology

A Free Precession Determination of the Proton Gyromagnetic Ratio. *P. L. Bender, R. L. Driscoll,* NBS, Washington, D.C.

The Absolute Determination of "g." *H. Preston-Thomas,* National Research Council, Ottawa, Canada

Atomic Beam Sources and the Standard of Length. *K. G. Kessler, R. L. Barger, W. G. S. Schweitzer,* NBS, Washington, D.C.

Thursday, August 14

8:45 a.m. Session 2

"Frequency and Time Interval Standards"
Chairman, W. A. Edson, General Electric Company

Ultra-Precise Quartz Crystal Frequency Standards. *A. W. Warner,* Bell Telephone Laboratories, Inc.

Use of Internal Friction Measurements in Determining the Causes of Frequency Instabilities in Mechanically Vibrating Frequency Standards. *W. P. Mason,* Bell Telephone Laboratories, Inc.

Cesium Beam Frequency Standard Development in Canada. *S. N. Kalra, R. Bailey, H. Damms,* National Research Council, Ottawa, Canada

The Ammonia Maser as an Atomic Frequency and Time Standard. *R. C. Mockler, J. Barnes, R. Beehler, H. Salazar, L. Fey,* NBS Boulder Laboratories

Results of Comparison: Atomichron—British Cesium Beam Standard. *A. O. McCoubrey,* National Company, Inc.

Recent Long-Distance Frequency Comparisons. *J. A. Pierce,* Cruft Laboratory, Harvard University

2:00 p.m. Session 3

"Direct Current and Low Frequency Standards"
Chairman, Chester Peterson, NBS, Washington, D.C.

Introductory Remarks: *F. B. Silsbee,* NBS, Washington, D.C.

The Derivation of Resistance, Inductance, and Capacitance from the NPL Standard of Mutual Inductance. *G. H. Rayner,* National Physical Laboratory, Teddington, England

The Construction and Characteristics of Standard Cells. *G. D. Vincent,* The Eppley Laboratories, Inc.

AC-DC Transfer Instruments for Current and Voltage Measurements. *F. L. Hermach,* NBS, Washington, D.C.

Inductronic Electro-Dynamometer. *R. F. Estoppey,* Weston Instruments, Division of Daystrom, Inc.

Precise Measurement of Small Capacitance. *A. M. Thompson,* National Standards Laboratory, Chippendale, Australia; read by F. K. Harris, NBS, Washington, D.C.

New Apparatus at NBS for Absolute Capacitance Measurement. *M. C. McGregor,* National Standards Laboratory, Chippendale, Australia; *J. F. Hersh,* General Radio Co.; *R. D. Cutkosky, F. K. Harris, F. R. Kotter,* NBS, Washington, D.C.

7:30 p.m. Session 4

"Radio Frequency Standards"
Chairman, D. C. Ports, Jansky and Bailey

High Frequency Standards of the NBS Electronic Calibration Center. *M. C. Selby,* NBS Boulder Laboratories

High Frequency Impedance Standards at the National Bureau of Standards. *R. C. Powell, R. M. Jickling, A. E. Hess,* NBS Boulder Laboratories

Calibration of Signal Generator Output Voltage in the Range 100 to 1,000 Megacycles. *G. U. Sorger, B. O. Weinschel, A. L. Hedrick, S. R. Raff,* Weinschel Engineering

Design and Development of a Standard White Noise Generator and Noise Indicating Instrument. *H. Zucker, Y. Baskin, S. I. Cohn,* Armour Research Foundation; *I. Lerner, A. Rosenblum,* U. S. Army Signal Engineering Laboratories, Fort Monmouth, N.J.

A Dry, Static Calorimeter for RF Power Measurement. *P. A. Hudson, C. M. Allred,* NBS Boulder Laboratories

Radio Interference from Power Sources. *R. M. Showers,* University of Pennsylvania; *W. E. Pakala,* Westinghouse Electric Corporation Research Laboratories

Friday, August 15

9:00 a.m. Session 5

"Microwave Standards"
Chairman, D. D. King, Electronic Communications, Inc.

New Orleans Section Chairmen

S. G. DINKEL (*left*) receives gavel from A. J. Lehman (*right*), outgoing chairman of the New Orleans Section of AIEE. Mr. Dinkel was installed as chairman for the 1958-59 year at the annual dinner-dance held May 24, 1958.

Recent Developments in the Field of Microwave Power Measurements at the National Bureau of Standards. *G. F. Engen,* NBS Boulder Laboratories

A New Estimating Method of Equivalence Error in the Microwave Microcalorimeter, *Sunichi Omori, Kenjiro Sakurai,* Electrotechnical Laboratory, Tokyo, Japan

The Theory of Low Temperature Bolometers Applied to the Measurement of Low Level RF Power. *D. L. Birx, N. Fuschillo,* The Franklin Institute Laboratories for Research and Development

Reproducible Gas Discharge Noise Sources as Possible Microwave Noise Standards. *K. W Olson,* Bendix Aviation Corporation

Recently Developed Microwave Impedance Standards and Methods of Measurement. *R. W. Beatty, D. M. Kerns,* NBS Boulder Laboratories

Precision Microwave Phase Shift Measurements. *Milton Magid,* Hughes Aircraft Co.

A Precision Calibrator for Microwave Demodulators. *Joseph Gindsberg,* Raytheon Manufacturing Co.

1:30 p.m. Session 6

"The Organization and Operation of Standards Laboratories"
Chairman, J. N. Whitaker, Hughes Research and Development Laboratories

Evolution of a Standards Laboratory. *C. E. White,* Avco R.A.D., Lawrence, Mass.

The Organization, Administration, and Operation of an Industrial Standards Laboratory. *J. N. Whitaker,* Hughes Research and Development Laboratories

A Centralized Facility for Electrical and Microwave Calibrations in a Large Company. *L. B. Wilson,* Sperry Gyroscope Co.

The Instrument Calibration Program within the Department of the Navy. *Lt. F. L. Roach, M. L. Scroggs,* Department of the Navy

Physical and Electrical Standardization Program for the AEC. *H. C. Biggs,* Sandia Corportion

Uniform Nomenclature for Standards. *A. G. McNish,* NBS, Washington, D.C.

As a special event of the Conference, the NBS will dedicate the new Electronic Calibration Center. This ceremony, from 10 a.m. to noon Tuesday, August 13, will precede the technical program. The formal dedication address will be given by the Honorable Walter Williams, Under Secretary of Commerce. Remarks will be given by Dr. P. D. Foote, Assistant Secretary of Defense, and by R. C. Sprague of the Sprague Electric Company. The Director, Dr. A. V. Astin, will speak for the NBS.

British IEE Presents Commemorative Books

The British Institution of Electrical Engineers (IEE) recently honored several Bell Telephone Laboratories engineers for the part they played in an historic international meeting held last year.

In an unusual international gesture, President T. E. Goldup of the IEE presented each of the engineers with commemorative volumes of papers they wrote for the Transatlantic Cable Symposium of January 1957. The presentation luncheon was held at the West Street branch of Bell Laboratories in New York City.

Most of the engineers honored are members of the Laboratories. Two are Western Electric men, one is from Long Lines, and one from the Canadian Overseas Telecommunications Corp.

Laboratories engineers included M. C. Biskeborn, F. J. Braga, J. W. Emling, H. B. Fischer, J. M. Fraser, T. F. Gleichmann, A. W. Lebert, H. A. Lewis, G. H. Lovell, J. O. McNally, G. W. Meszaros, E. T. Mottram, H. H. Spencer, R. S. Tucker, E. A. Veazie, M. C. Wooley. Another of the authors, A. H. Lince, was presented with a commemorative volume during a recent trip to London.

Other Bell System authors were W. W. Heffner and H. A. Lamb of Western Electric and J. S. Jack of Long Lines. R. G. Griffith, another author, is with the Canadian Company.

President Goldup also presented copies of the volume to Dr. Kelly, who was also an author of a paper, W. J. Barrett, president of the AIEE and a member of the New Jersey Bell Telephone Company, and L. A. Wright, general secretary of the Engineering Institute of Canada (EIC).

The 1957 symposium was the first joint meeting of engineers in the United States, Canada, and England, connected across the Atlantic by the new submarine telephone cable. Participating in the conference were the AIEE, the IEE and the EIC (*Electrical Engineering,* April 1957, p. 325).

A. Q. Adamson Named Winner of Marston Medal

A. Q. Adamson was announced at the June commencement exercise at Iowa State College, Ames, as the 1958 winner of the Marston Medal. The medal is given annually to a graduate in recognition of outstanding achievement in the field of engineering.

Mr. Adamson was born a birthright Quaker on a farm near Ankeny (north of Des Moines, Iowa), in 1881, and graduated in civil engineering from the Iowa State College in 1907, After two years on the YMCA staff in Salt Lake City, Utah, he went to China to take charge of an extensive building program there. In the next 20 years he acquired a knowledge of two Chinese dialects, and completed eight YMCA buildings designed by a Chicago architect. He also designed and completed 14 YMCA buildings and 24 residences for American staff members. The buildings under his charge were constructed in 24 different cities in China and cost well over $3.5 million. While in China, Mr. Adamson took an active part in numerous civic activities and was president of the Shanghai Short Story Club and the Rotary Club in Hankow.

When the building program in China was completed in 1928, he returned to the United States. Soon, however, his services were needed in Palestine where a YMCA building was to be erected in Jerusalem. After many obstacles were overcome, the building was completed in 1933.

From 1933 to 1940, Mr. Adamson was with the Public Works Administration. In 1940, he was asked to return to China to look after the Army and Navy YMCA facilities. He was in Shanghai when the Japanese attacked. After being interned for three years, he was repatriated in 1943. Having passed the retirement age for YMCA work, he returned to his home in California.

In 1944, he returned to active life as a director of the building service department of the Western Area USO. In 1948, he retired a second time to his California home in Los Gatos.

He was made a life member of the American Society of Civil Engineers in 1951. The Iowa State College Alumni Merit Award was presented to him in 1957.

DR. M. J. KELLY *(left)*, president of Bell Telephone Laboratories, receives a commemorative volume of the Transatlantic Cable Symposium papers from T. E. Goldup, president of the Institution of Electrical Engineers (IEE) of England. Others are *(left to right)* Dr. L. A. Wright, general secretary, the Engineering Institute of Canada; W. K. Brasher, secretary of the IEE; and W. J. Barrett, president of the AIEE.

Mr. Adamson is the 20th winner of the Marston Medal. The award has been made each year since 1938, except for one year during World War II. It is presented to an alumnus of the college in recognition of outstanding achievement in the field of engineering and is presented in honor of the late Dean Anson Marston of the Division of Engineering.

To be eligible, the candidate must have an earned degree in some branch of engineering at Iowa State College. An alumnus must have at least 30 years standing in engineering.

The award is made by a board consisting of four alumni, one honorary member, each of the AIEE, American Society of Civil Engineers, American Society of Mechanical Engineers, and American Institute of Chemical Engineers, and the Dean of Engineering who serves as *ex-officio* chairman of the board.

Petroleum Conference Scheduled for September 15-17

The fifth AIEE Electrical Conference of the Petroleum Industry will take place in Dallas, Texas, September 15-17, 1958. Headquarters for the Conference will be the Baker Hotel.

The tentative technical program follows.

Sunday, September 14

4:00 p.m. Registration—Mezzanine

4:00 p.m. Reception—Texas Room

Monday, September 15

8:00 a.m. Registration—Mezzanine

10:00 a.m. General Session—Ballroom

Presiding: D. S. Coffman, Texas Power & Light Co., Conference chairman

Welcome by Mayor

Keynote Address

Static Switching—Where It Stands Today and What It Promises for the Future. *Dr. R. A. Ramey, Jr., C. R. Olson,* Westinghouse Electric Corporation

12:00 Noon General Luncheon

Presiding: L. E. Oberhelman, Standard Oil Company of Indiana, outgoing chairman of AIEE Petroleum Industry Committee

Luncheon Speaker

2:00 p.m. Refining—Banquet Rooms 1, 2, and 3

Presiding: H. M. Stewart, Humble Oil & Refining Co.

Instantaneous Power System Load Control by Logic Static Switching. *R. A. Wise,* Bechtel Corporation; *F. K. Fox,* General Electric Company

Protective Relays in Oil Refineries (author and title to be announced)

Characteristics of Pumps and Compressors which Affect the Motor Drive under Transient Conditions. *L. B. Eddy,* Universal Oil Products Co.; *H. A. Weigand,* Ingersoll-Rand Co.

Control and Protection of Large Refinery Motors with Metal-Clad Switchgear. *E. R. Brucklacher, A. H. Knable,* Allis-Chalmers Manufacturing Company

2:00 p.m. Transportation—Terrace Room

Presiding: M. A. Hyde, Westinghouse Electric Corporation

Wilhelmshaven–Cologne Pipeline. *R. S. Cannon,* Plantation Pipe Line Company

Economics in Pipeline Engineering. *F. V. Whitney,* El Paso Natural Gas Co.

Considerations in Selecting Prime Movers for Pipeline Pumping. *O. F. Zedler, Jr.,* Humble Pipeline Co.

Electrical Features of the Four Corners Pipe Line. *J. J. Sonnier, H. Siler,* Shell Pipe Line Corp.

2:00 p.m. Production—Ballroom

Presiding: C. H. Eckel, Humble Oil & Refining Co.

Remote Operation of Offshore Gas Condensate Production. *V. L. Ackerman, W. K. Lewright,* Pure Oil Co.

Electric Power and Remote Controls for Offshore Production on Phillips Eugene Lease. *R. W. Elliott,* Phillips Petroleum Co.

Lease Automatic Custody Transfer. *J. W. Montgomery,* Shell Oil Company

6:00 p.m. Cocktail Hour and Banquet—Terrace Room

Presiding: D. S. Coffman

Tuesday, September 16

8:00 a.m. Transportation—All Day Inspection Trip

7:30 a.m. Production—All Day Inspection Trip

9:00 a.m. Refining—Texas Room

Presiding: H. M. Stewart, Humble Oil & Refining Co.

Problems Associated with Application of Large Synchronous Drives to FCC Unit. *S. P. Axe,* Atlantic Refining Company; *F. A. Leinberger,* General Electric Company

Application of an 11,000-Hp Synchronous Motor to a Refining Unit. *K. R. Sheetz, E. L. McHenry,* Standard Oil Company of Indiana

Large Squirrel-Cage Induction Motors in Refinery Service. *G. H. St. Onge,* Esso Research and Engineering Company

The Concept of "In Phase" Transfer Applied to Industrial Systems Serving Essential Service Motors. *C. C. Young, J. Dunki-Jacobs,* General Electric Company

12:30 p.m. Luncheon—Refining Group

2:00 p.m. Refining—Texas Room

"Panel Discussion on Large Motors"
Scope: I. The Viewpoint of Users
II. The Viewpoint of Manufacturers
III. The Viewpoint of Utility Suppliers
IV. The Viewpoint of Consultants

8:00 p.m. Production Subcommittee Meeting

Presiding: C. H. Eckel, Subcommittee chairman

Wednesday, September 17

9:00 a.m. Production—Lounge Room

Presiding: C. H. Eckel, Humble Oil & Refining Co.

The Proper Selection of Control Material in Contactor Relays and Motor Starters. *A. J. Zavada,* Electric Controller Products

Normal Slip vs High Slip Motors. *Frank Beach,* Cities Service Oil Co.; *J. H. Day, Jr.,* General Electric Company; T. L. Scott, Phillips Petroleum Co.

9:00 a.m. Transportation—Texas Room

Presiding: C. D. Catt, El Paso Natural Gas Co.

The Pipeline Industry's Use of the Tools of Automation. *E. B. Turner,* General Electric Company

Recent Developments in Supervisory Control for Pipelines. General Electric Company

9:00 a.m. Panel Discussion on Batch Interface Detectors

Moderator: C. F. Barnard, Pipeline Engineering Co.
C. V. Baxter, Salt Lake Pipeline Co.
C. W. Blackburn, Phillips Petroleum Co.
R. R. Hancox, Great Lakes Pipeline Co.
W. W. Holt, Jr., Plantation Pipeline Co.
R. L. Smith, Southeastern Pipeline Co.

9:00 a.m. Refining—Terrace Room

Presiding: L. B. Eddy, Universal Oil Products Co.

Power and Control Cables for Oil Refineries. *B. J. Mulvey, J. Dunki-Jacobs, E. R. Kerwin,* General Electric Company

Outdoor Explosionproof Division 2 Electrical Service for a Refinery Process Unit. *W. R. Smith,* Humble Oil & Refining Co.

The Use of Aluminum Conduit on Cooling Towers. *H. M. Tomlinson, Jr.,* Celanese Corporation

12:00 Noon Luncheon and Petroleum Industry Committee Meeting—English Room

2:00 p.m. Production—Lounge Room

An Electric Rig. *E. House,* Reliance Electric & Engineering Co.

Diesel Electric Drilling Equipment. *T. A. Gallagher, W. R. Jones,* Alco Products, Inc.

2:00 p.m. Transportation Subcommittee Meeting—Texas Room

Presiding: C. D. Catt, new chairman of Transportation Subcommittee

2:00 p.m. Refining Subcommittee Meeting—Terrace Room

Presiding: L. B. Eddy, new chairman of Refining Subcommittee

Successful Western Joint Computer Conference Held

On May 6-18, the very successful 1958 Western Joint Computer Conference, "Contrasts in Computers," was held at the Los Angeles (Calif.), Ambassador Hotel. Regarded by the Conference Committee as the "150% Conference" because every event—technical as well as social—was about half again as large as predicted, the Conference registered a total of over 1,800 people. It was the largest of the Western Conferences thus far.

An outstanding program was presented by the Technical Program Committee. In the keynote session which was devoted to exploring the possible social problems which may arise from widespread automation, a number of very intriguing and significantly new computer applications in the social and behavioral sciences were suggested. Six invited panel discussions presented and explored several of the controversial questions of the present computer art and six sessions of contributed papers described some of the recent advances in computer hardware and computer applications. A "bonus feature" of

the technical program was the added technical session devoted to a paper describing the recently announced French Gamma-*60* computer.

Some 50 exhibitors demonstrated recent components, equipment, techniques, and company progress in the 80 booths of the exhibit area. The social events of the Conference—the women's activities, the cocktail party, and the luncheon—were all oversubscribed, and contributed to the success of the Conference.

Following the Conference, a one-day Symposium on "Small Automatic Computers and Input/Output Equipment," was sponsored by the Los Angeles Chapter of the Association for Computing Machinery (ACM), and attended by 350. Eight papers from the manufacturers described their latest equipment.

Proceedings of the Conference will be published in the late fall of 1958 and will be available to nonregistrants from the three cosponsoring societies: AIEE, ACM, and Institute of Radio Engineers. A Proceedings of the Symposium will be published at a later date by the ACM.

American Automatic Control Council Officers

The American Automatic Control Council has adopted a Constitution with the approval of the constituent societies which are: AIEE, American Society of Mechanical Engineers, American Institute of Chemical Engineers, Institute of Radio Engineers, and Instrument Society of America.

An election of officers was held by mail ballot with the following results: President—Prof. Rufus Oldenburger (M '55), School of Mechanical Engineering, Purdue University, Lafayette, Ind.; Vice-President—Dr. J. C. Lozier, Bell Telephone Laboratories, Whippany, N. J.; Secretary-Treasurer—W. E. Vannah, *Control Engineering*, McGraw-Hill Publishing Company, 330 W. 42nd St., New York 36, N. Y.

The officers were elected to serve until the end of 1959.

Results of the District Student Papers Competition

The winners of the AIEE District Student Prize Papers Competition have been announced.

In addition to the $25 Institute award to each first prize winner in the District, the Members-for-Life Fund has provided additional prizes which include a trip to the Summer General Meeting for the first prize winners, $25 for second prize, and $15 for third prize.

The following students are the recipients of these awards.

District No. 1

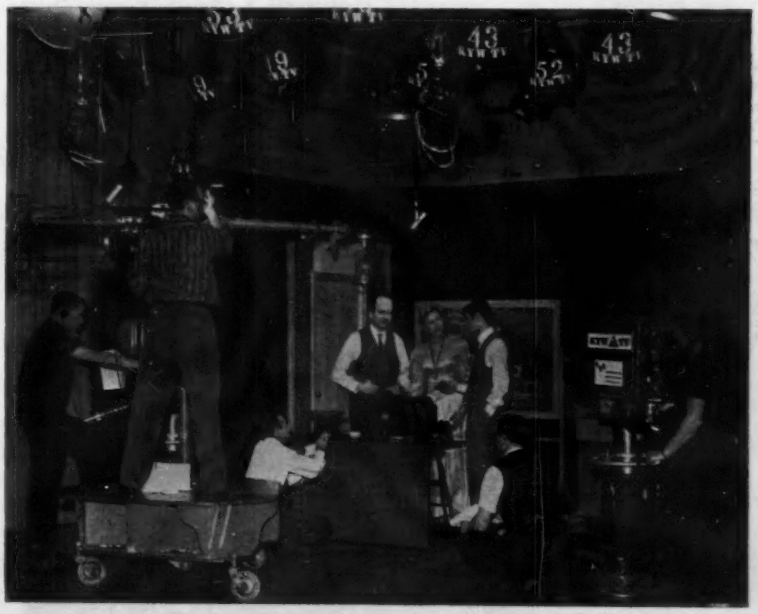
1. M. W. Musbach, Union College, "Communications System for Scuba Divers."

2. David Gross, Rensselaer Polytechnic Institute, "A Liquid Level Senser."

Spokane Section Officers for 1958-59

R. D. BROWN (*left*), outgoing chairman, greets the incoming officers of the AIEE Spokane, Wash., Section for the year 1958-59: (*left to right*) L. C. Ford, chairman; W. A. Morgan, vice chairman; J. A. Wright, executive board; J. F. Eyrich, secretary-treasurer; and L. W. DeMaster, executive board. W. A. Heineck, executive board, is not present.

AIEE Cleveland Section on TV



THE CLEVELAND SECTION OF AIEE recently sponsored a television program portraying important electrical engineering events contributing to our high standard of living. The development of a transformer by George Westinghouse that successfully harnessed alternating current and enabled man to embark on a new industrial era was highlighted on the local Cleveland television show, "Breakthrough," on Sunday, April 20. In scene above, actors portraying Mr. Westinghouse, his wife, Patricia, and his close associate, William Stanley, discuss the possibility of redesigning the transformer to transmit alternating current. Basic features incorporated on that early transformer have been standard ever since. "Breakthrough" is a joint project of KYW-TV and the Cleveland Technical Societies Council. John Ponstingl, AIEE Television Committee, Westinghouse Electric Corporation served as technical adviser for this program.

3. W. H. Leipold, University of Buffalo, "The Logic Circuit Simulator."

District No. 2

1. I. E. Sutherland, Carnegie Institute of Technology, "Parallels, Men, and Machines."
2. Azatollah Farokhrooz, Lafayette College, "The Distribution of Current along Center Fed Cylindrical Antennas."
3. C. W. Hardy, Johns Hopkins University, "Operational Amplifiers in Analog Computors."

District No. 3

1. Peter Hirsch, Polytechnic Institute of Brooklyn, "Linear Phase Transistor Amplifiers."
2. Saul Walker, New York University, "A Complementary Symmetry Multivibrator."
3. A. R. Lopez, Manhattan College, "A Unique Analysis of a Half Wave Diode Rectifier."

District No. 4

1. Copthorne Macdonald, University of Kentucky, "A Slow-Scan TV System for Image Transmission."
2. W. E. Montgomery, Duke University, "An Electronic Microscope."
3. B. W. Daugherty, V. E. Rochat, University of Tensessee, "The Passive Analog Computer."

District No. 5

1. J. A. Lauder, University of Michigan, "An Electronic Random Number Generator."
2. R. F. Green, Marquette University, "Nuclear Batteries."
3. Paul Scheibe, University of North Dakota, "Phase-Locked Oscillator Systems as Applied to Double Sideband Suppressed Carrier Communications."

District No. 6

1. A. P. Wilson, South Dakota School of Mines and Technology, "Two Variable Comparison with Factorial Experimentation as Applied to the Static Characteristic of a Transistor."
2. P. G. Bernard, University of Nebraska, "Toward a Universal Test of Vacuum Tubes."
3. P. C. Callan, South Dakota School of Mines and Technology, "An Amplidyne Voltage Regulator."

District No. 7

1. J. R. Cox, Texas A & M College, "Grid Current Measurements with a D-C Analog Computer."
2. D. C. Watkins, Rice Institute, "Investigation of Unstable Linear Networks by the Application of Feedback Techniques."
3. D. P. Maragni, University of St. Louis, "Methods of Load Forecasting."

District No. 8

1. A. R. Wilson, R. A. Mintz, California State Polytechnic Institute, "A Serial Binary Adder for a Digital Computer."
2. R. D. Young, University of Arizona, "A Passive Reactance Modulator."
3. Douglas MacMillian, University of California (Berkeley), "Oscillatory Characteristics of a Saturable Reactor."

District No. 9

1. D. B. Ulm, Myron Hurlbut, Oregon State College, "Effects of Phase Shift Between Applied Voltages of a Magnetic Amplifier."
2. W. S. Perkes, N. C. Rigby, University of Utah, "A Small Relay Digital Computer."
3. G. A. Rodeman, Washington State College; Richard Daniel, University of Alaska; W. T. Booth, Montana State College.

District No. 10 (No Contest)

District No. 11

1. W. C. Susor, University of Toledo, "Design of Nuclear Reactor Simulator for Control System Testing."
2. R. A. Thompson, R. G. Tomlinson, Case Institute of Technology, "Polarization Studies of Satellite Signals."
3. P. L. Klingenmeier, University of Cincinnati, "Design and Construction of a Variable Bandwidth I.F. Filter."

District No. 12

1. Robert Doyle, Northeastern University, "Cathode-Ray Tube Gun Design for Storage Tube Application."
2. J. C. Sethares, University of Massachusetts, "A Voice Operated Typewriter."
3. D. H. Wordell, Bradford-Durfee Technical Institute, "Solutions for Absolute Inequalities."

Conference on Application of Electrical Insulation Planned

The First National Conference on the Application of Electrical Insulation, to be held in Cleveland, Ohio, September 3-5, 1958, is being cosponsored by the AIEE and the National Electrical Manufacturers' Association (NEMA). The purpose is to provide a meeting ground for the maker and user of electrical insulation where there can be a mutual interchange of practical technical information on a formal and informal basis, thereby leading to better utilization of existing materials, to better direction in the development of new materials, and to better methods of interchanging information.

This will be the first meeting of this type ever held in the United States attracting everybody either directly or indirectly interested in electrical insulation, both for military and civilian purposes. Attendance of between 1,500 and 2,000 is anticipated.

Activities at Cleveland will include technical sessions, a commercial trade show exhibiting electrical insulation materials, and technical exhibits by manufacturers of electrical equipment.

In addition to the cosponsors, other technical societies and trade associations are participating in the counseling and preparation of the program of this, the first industry-wide conference ever devoted exclusively to electrical insulation materials.

NEW AIEE FELLOWS receive diplomas from Philadelphia Section members: (*left to right*) N. E. Funk, J. H. Harlow, J. H. Neher, A. H. Kidder, all of the Philadelphia Electric Company; and C. H. Titus, V. L. Cox, of the General Electric Company.

Philadelphia Section Hears Panel on Engineering Shortage

The May Main Section meeting of the AIEE Philadelphia Section featured a panel on "The Engineering Shortage—Fact or Fancy." Participants were: Dr. W. H. Chartener, department of economics, McGraw-Hill Publications; P. H. Robbins, executive director, National Society of Professional Engineers; and J. Amann, president, Engineers and Scientists of America. The panelists denied that there was any present shortage of engineers in spite of the current belief to the contrary. Dr. Chartener, however, said that an increasing demand for engineers will create a shortage in the coming years. All said that more encouragement should be shown engineers with great abilities.

T. A. Smith, executive vice-president,

industrial electronic products, Radio Corporation of America, spoke at the April Main Section meeting on "Communications—The Growing Servant of Industry." He showed how the communications field has progressed during the past and described some of the major breakthroughs. Mr. Smith envisions widespread use of radio in place of phone lines in many of the world's more remote and backward areas. He also stated that communication between the Earth and manned rockets or satellites would merely be an extension of the system now used to obtain information from unmanned satellites.

Fellow Diplomas were presented at this meeting to the following members of the Section: J. H. Harlow, J. H. Neher, and C. H Titus.

Mr. Harlow, chief mechanical engineer of Philadelphia Electric Company, was awarded his diploma by N. E. Funk, retired vice-president of the Philadelphia Electric Company and a former national president of the AIEE. Mr. Harlow is a member of the Recognition Committee of the Engineers' Council for Professional Development. Mr. Neher, senior engineer of the Electrical Research Section, Philadelphia Electric Company, was presented his diploma by A. H. Kidder, research engineer of the Philadelphia Electric Company. Mr. Neher is chairman of the Committee on Science and the Arts of Philadelphia's Franklin Institute and is the holder of several patents on protective equipment. Mr. Titus is manager–engineering, Engineering Research and Development Laboratory, General Electric Company Switchgear and Control Division. He is the holder of patents on various electromechanical devices. His diploma was awarded by V. L. Cox, manager of the switchgear laboratories department.

Conference Papers Open For Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until August 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y., on or before August 27.

57-776 **Reactions of Bistable B-H Loops on Magnetic Amplifiers.** *R. E. Morgan*

57-1161 **The Use of Electricity for House Heating in the Tennessee Valley.** *B. H. Martin*

58-106 **Some of the Fundamental Aspects of Ground Resistance Measurements.** *E. B. Curdts*

58-223 **Comparison of Calculated and Measured Arc-Back Current in Large Power Rectifier Systems.** *J. Teno, C. H. Titus, R. N. Wagner*

58-225 **Field Testing D-C Air Circuit Breakers on a High-Capacity System.** *P. L. Hartsock, T. J. Scully, V. N. Stewart*

58-226 **A Mathematical Model and Procedure for Arc-Back Current Calculations for Power Rectifiers.** *H. P. Fullerton, J. Teno*

58-532 **Measurement of the Scattering Matrix with an Intervening Ionosphere,** *H. Brysk*

58-534 **Spinning Disk Random Selectors.** *G. A. Roberts*

58-538 **The Analysis of Redundancy Networks.** *F. Moskowitz*

58-575 **Operations Research in Communications.** *B. Harris, A. Hauptschein, L. S. Schwartz*

Also the following papers presented at the third Nuclear Engineering and Science Conference held during the 1958 Nuclear Congress:

58-700 **An Electronic Feedwater Control System for the Experimental Boiling Water Reactor.** *R. H. Morse, R. N. Brey, Jr.*

58-702 **Main Coolant Instrumentation for High-Performance Pressurized Water Reactor Power Plants.** *L. C. Noyes*

58-703 **Steam Generator Instrumentation for a Nuclear Power Plant with Analog Computer Verification of Dynamic Action.** *E. E. Lynch, D. P. Waite*

58-708 **Modular Concepts in Reactor Control Instrumentation.** *J. L. Cockrell, D. F. Ryan, J. H. Magee*

58-709 **Variation of the Trip Point in the ORNL-Type Safety System.** *J. L. Cockrell, C. W. Ricker*

Reprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

Section Study Groups Based on AIEE Red Book

In October 1956, the AIEE released publication No. 952 on "Electrical Power Distribution for Industrial Plants," commonly known as the Red Book. This publication was prepared by the Electric Power Distribution for Industrial Plants Subcommittee of the Industrial Power Systems Committee, and represents the knowledge and experience of over 80 top flight industrial electrical engineers.

The purpose of this publication is to bring to the attention of engineers, owners, and plant management the important features of well designed electrical distribution systems that result in satisfactory performance of utilization equipment and efficient operation of the plant. However, this publication is not fulfilling its purpose when copies are gathering dust in the mailing room at National Headquarters.

One way to circulate this publication is through study groups on industrial power distribution systems which have been formed in various AIEE Sections.

The purpose of these study groups is to bring to the attention of management, electrical engineers, contractors, etc., the part that power distribution plays in the activity of a manufacturing plant. The reasons for good power distribution are found in publication No. 952, but unless management can be convinced of the need for a better distribution system, the Red Book cannot do much to eliminate the many inadequate and unsafe systems in the country. The audience participating in these study groups indicates that power distribution is "everybody's business." By "everybody" we mean not only members of AIEE or people directly connected with the electrical industry, but all plant operating personnel including owners, various

STUDY GROUP in action in Detroit, Mich. This is one of the study groups which have been organized on "Electric Power Distribution Systems" in the various AIEE Sections throughout the United States.

types of engineers, and management personnel who, on the surface, seem far removed from power distribution. The attendance record of 90% or better at each meeting of these study groups indicates that, regardless of their level of manufacturing, the audience found the subjects covered to be of great interest.

The benefits of study groups to the AIEE are twofold. One, and perhaps the greatest benefit, is in reaching the vast audience of people with whom electrical engineers are in constant contact, and demonstrating to them that their engineering society is interested in all phases of engineering which touch their fields of endeavor. In many sections, the AIEE is looked upon as an organization composed of college professors and scientists who struggle with problems of highly complex and involved equipment restricted in most cases to the laboratory. Electrical engineers are often accused of hiding behind the "smoke screen" of highly technical terms and glossary in order to mystify their fellowmen with their productive output. The study groups have demonstrated that basic problems can be explained to the laymen especially where that layman has the power of saying "yes" or "no" to any proposal for much needed electrical equipment. There are few mysteries in industrial power distribution systems which cannot be explained to a plant manager in understandable terms.

Each study group should be built around local needs. The number of meeting nights and topics covered at each meeting are a problem which can best be worked out by the individual Section.

Wherever possible, local speakers should be obtained. In the larger cities this is no problem as the various electrical manufacturing companies offer a large pool of talent. In smaller localities, such as the Newark, Ohio, area, the speakers have to come from outside the local area. As the registrations come in, it is well to advise the speakers concerning the people who plan to attend so that they may prepare their talk for the typical participant.

The second benefit to AIEE is in recruiting new members. The study group, in many cases, is the first contact that many electrical engineers have with the activities of the Institute. Many Sections have reported increased membership requests as a direct result of study group activity.

The study groups can also be a source of revenue to help defray Section expenses. The fee charged for participation can, in the larger groups, amount to a considerable amount. This money can be used to further Section activities, such as individual lectures, dinners, and college activities. An example is presented by one of the larger Sections where an announcement of a study group on industrial power distribution brought forth 390 registrations at $10 a piece, necessitating two sessions in view of the fact that only 240 could be accommodated in the auditorium.

Wherever study groups have been started, they have become a very valuable asset to the Section in which they operate, and it is felt that the Institute will benefit by such study groups in the future.

Further information on the organization and operation of study groups may be secured from the Industrial Power Systems Committee Chairman, R. T. Woodruff, Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.; or from J. W. St. Andre, Chairman of the Electrical Power Distribution for Industrial Plants Subcommittee, c/o Kaiser Aluminum & Chemical Corporation, Newark, Ohio.

U.S. Government Awards Under Fulbright Act for 1959-60

U. S. Government Awards authorized by the Fulbright Act are being offered for university lecturing and advanced research for 1959-60.

Countries participating are: *Europe*—Austria, Belgium and Luxembourg, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, United Kingdom; *Near East and Africa*—Iran, Israel, Turkey, British Colonial Territories in Africa; *Far East*—Republic of China, Hong Kong, Japan, Singapore.

Applicants must be citizens of the United States. Those applying for visiting lectureships are expected to have had at least one year of college or university teaching experience in the United States or abroad at a level equivalent to that for which application is made. Applicants for research awards are expected to have a doctoral degree from a recognized institution of higher learning in the United States or abroad at the time of application, or recognized standing in their respective professions. (Candidates for the doctoral degree, or those expecting to obtain it in the normal course of their training, should apply to the Institute of International Education, 1 E. 67th St., New York, N. Y.)

The awards, tenable in one country, usually for an academic year, and payable in currency of the host country, include: round-trip travel for grantee, but not for members of his family; a maintenance allowance to cover ordinary living expenses of grantee and family while in residence abroad; and a small incidental allowance for travel, books, and services required in performance of assignment.

Application forms and additional information are obtainable from: Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Ave., Washington 25, D.C.

The closing date for applications is October 1, 1958.

Philadelphia Section Auxiliary Aids Education

On March 27, the Women's Auxiliary to the Philadelphia Section of AIEE presented a gift of $500 to the department of electrical engineering of Princeton University at Princeton, N. J. The money is to be used to purchase laboratory equipment.

A delegation representing the Executive Board, the Education Committee, and the Ways and Means Committee journeyed to Princeton to present the award. In the group were Mrs. G. B. Schleicher, chairman of the Auxiliary, who made the presentation; Mrs. W. N. Gittings, secretary and chairman elect; Mrs. E. A. Bailey, treasurer; Mrs. B. L. Farmery, corresponding secretary; Mrs. Gordon Perkins, membership chairman; Mrs. J. B. Clothier, ways and means chairman, and Mrs. J. E. Casey of the same committee; Mrs. B. H. Zacherle and Mrs. Olaf Vikoren of the Education Committee. Mrs. W. F. Henn, chairman of the Education Committee, was unable to attend due to illness. The gift was accepted on behalf of the University by Dr. J. C. Elgin, dean of the Engineering School, and Prof. W. C. Johnson, chairman of the department of electrical engineering.

Awards in previous years included a four-year partial scholarship to the Uni-

MRS. G. B. SCHLEICHER, chairman of the Philadelphia Section Women's Auxiliary, presents $500 check to Dr. J. C. Elgin (*right*), dean of Princeton Engineering School. At left is W. C. Johnson, chairman of the department of electrical engineering.

versity of Pennsylvania and monetary gifts for the purchase of equipment to Drexel Institute of Technology, Swarthmore College, and Villanova University. All are accredited schools in the Philadelphia Section area. In the past six years, the Auxiliary has contributed $2,000 to electrical engineering education. The Auxiliary has a membership of 230 and celebrated its 10th anniversary this spring.

EIC Appoints New General Secretary

Dr. G. T. Page, of Ottawa and Montreal, has been appointed general secretary of The Engineering Institute of Canada (EIC), Canada's largest national professional organization.

The appointment was announced by K. F. Tupper, Toronto, president of the EIC. Dr. Page succeeds L. A. Wright who has retired after 20 years of service as general secretary.

Dr. Page was formerly general manager and secretary of The Chemical Institute of Canada. He joined EIC as assistant general secretary in the Fall of 1957. He will make his headquarters in Montreal but will be required to travel extensively visiting the 50 branches of the 18,000 member organizations.

AIEE and ASME To Sponsor National Power Conference

AIEE and the American Society of Mechanical Engineers (ASME) will jointly sponsor the National Power Conference to be held in Boston, Mass., September 29-October 1, 1958.

The tentative technical program for the Conference follows.

Monday, September 29

Session I Morning
Steam Power Plant Station Design

A Look at the Future of Steam Station Design. *E. H. Krieg,* Stone & Webster Engineering Corporation

Relay Protection Practices in Steam Power Stations. *H. C. Barnes,* American Electric Power; *C. S. Murray,* Consolidated Edison Co.; *V. E. Verrall,* Central Illinois Public Service Co.

Session II Afternoon
Major Steam Plant Component Design

Modern Large Steam Turbines and Generators. *C. C. Franck, Sr., J. W. Batchelor,* Westinghouse Electric Corporation

Mechanical and Electrical Features of Large Steam Turbine Generators. *S. C. Barton, J. A. Massingill, H. D. Taylor,* General Electric Company

Current Large Steam-Turbine-Generator Design Practice. *J. J. Fleischmann, G. W. Staats,* Allis-Chalmers Manufacturing Company.

Session III Evening
Career Possibilities for Young Engineers in the Power Field

Engineering Institute of Canada

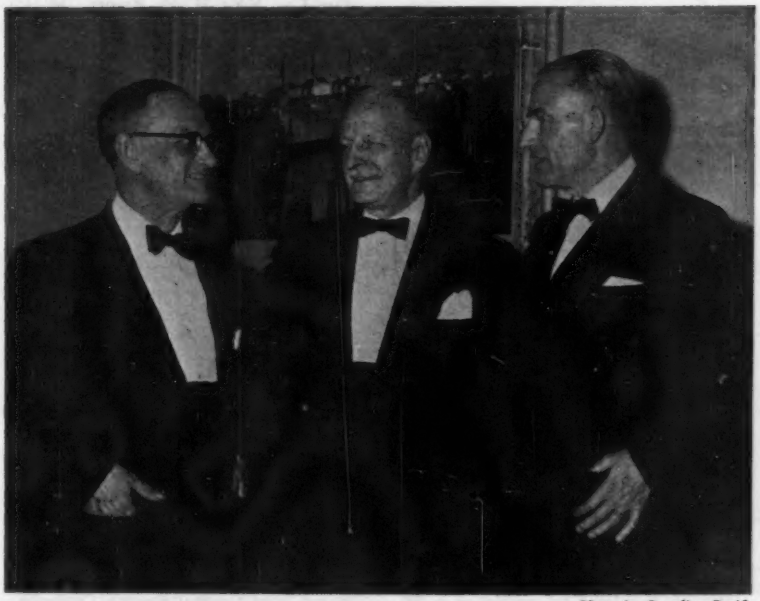


Photo by Canadian Pacific

DURING the 72nd Annual Meeting of the Engineering Institute of Canada (IEC), held in the Chateau Frontenac Hotel, Quebec City, C. M. Anson gave a dinner to honor the officers and past officers of the IEC. Every province of Canada was represented at this meeting as well as the leading British Engineering Societies. Shown (*left to right*) are: C. M. Anson, Sydney, N.S., immediate past president of the IEC; L. A. Wright of Montreal, retiring general secretary; and K. F. Tupper of Toronto, newly elected president.

The Graduate Mechanical Engineer in the Power Industry. *J. W. Keenan,* Massachusetts Institute of Technology (MIT)

Expanding Horizons for the Graduate Engineer in Electric Power. *Gordon Brown,* MIT

Power and Growth: The Challenge and the Promise. *F. A. Kramer,* Public Service Electric & Gas Co.

Career Possibilities for Young Engineers in the Power Field. *V. F. Estcourt,* Pacific Gas & Electric Co.

Session IV Evening
Steam Plant Auxiliary Design

Pumping Power in the Feed Water Cycle. *S. N. Arnow, J. L. Allen,* Philadelphia Electric Co.

Integration of Single Turbine-Driven Feed Pumps in Large Generator Units. *S. N. Fiala,* American Electric Power Company

Evolution of the Boiler Feed Pump Drive. *R. A. Baker,* Public Service Electric & Gas Co.

Auxiliary Power for Eddystone Station. *J. A. Adams,* Philadelphia Electric Co.

Tuesday, September 30

Session V Morning
Nuclear Power and Marine Power

Yankee Atomic Power Plant. *R. J. Coe,* Yankee Atomic Power Co.; *W. E. Shoupp,* Westinghouse Electric Corporation

A 125-Mw Pebble Bed Nuclear Power Station. *R. F. Benenati,* Sanderson & Porter Engineers

The Dresden Nuclear Power Station. *V. A. Elliott, V. D. Dixon,* General Electric Company; *R. D. Maxson,* Commonwealth Edison Co.; *J. W. Merryman,* Bechtel Corporation

Enrico Fermi Atomic Power Plant. *R. W. Hartwell, A. P. Donnell, and H. A. Wagner,* Power Reactor Development Co.

Performance Tests of a Vertical Steam Generator for Nuclear Power Plants. *R. L. Coit, C. C. Peake,* Westinghouse Electric Corporation

Boiling Water Reactor Proposed for Tanker Conversion.

Wednesday, October 1

Session VI Morning
Operations and Economics I

Operating Experience in the Illinois–Missouri Power Pool. *T. W. Schroeder, E. A. Shultz,* Illinois Power Co.

Five Years' Experience on the Consolidated Edison System with Protection of Turbine Generators and Boilers by Automatic Tripping. *W. C. Beattie, J. M. Driscol, P. T. Onderdonk, H. A. Bauman, R. L. Webb,* Consolidated Edison Co.

D-C Transmission—An American Viewpoint. *G. D. Breuer, M. M. Morack, L. W. Morton, C. A. Woodrow,* General Electric Company

Session VII Afternoon
Operations and Economics II

Trends in Steam Generator Design. Riley Stoker Company

Trends in Steam Generator Design. Babcock and Wilcox Co.

Trends in Steam Generator Design. Combustion Engineering Co.

Industrial Power Planning. *A. Kirkpatric,* Charles T. Main Co.

Trends in Power Plant Design for Modern Paper Mills. *T. J. Judge,* International Paper Company

NEC Holds Recognition Dinner

Some 21 top engineers, researchers, and educators were honored—two of them posthumously—by the National Electronics Conference (NEC) at a recognition dinner Saturday, June 7, in Chicago, Ill.

They are all former presidents and chairmen of the board of NEC, the nation's leading forum on electronic research, development, and application.

Dr. J. D. Ryder, dean of Michigan State University's School of Engineering, spoke at the dinner in the Sherman Hotel's Skyline Terrace Club. J. H. Enenbach (AM '51), NEC president and supervising engineer of Illinois Bell Telephone Company, presented the awards.

"These men are in a large part responsible for the growth of the National Electronics Conference and the world-wide recognition it enjoys among the leaders in the electronics industry and education," Mr. Enenbach said.

The honored guests, who came to Chicago from all over the United States, were together for the first time in the 14-year history of the NEC, a nonprofit organization.

Mrs. M. Dorothy Graf, widow of A. W. Graf, and Mrs. Myrtle S. Westerberg, widow of O. D. Westerberg, accepted awards.

Others to be honored are: Kipling Adams, district office manager, General Radio Co.; G. E. Anner, professor of electrical engineering, University of Illinois; Dr. C. E. Barthel, Jr., assistant director, Armour Research Foundation; R. R. Batcher, consulting engineer, Hudson Wire Co., N.Y.; H. H. Brauer (M '43), staff assistant, Fansteel Metallurgical Corp.; Dr. A. B. Bronwell (M '44), president, Worcester Polytechnic Institute; J. M. Cage (M '44), research engineer; Hewlett-Packard Co.; Nathan Cohn (F '54), head, market development section, Leeds & Northrup Co.; W. G. Dow (F'48), professor of electrical engineering, University of Michigan; Dr. G. H. Fett (M' 38), professor of electrical engineering, University of Ill. Dr. J. E. Hobson (F '48), vice-president, United Fruit Co.; R. R. Jenness (M '51), associate professor of electrical engineering, Northwestern University; Dr. J. A. M. Lyon (M '47), professor of electrical engineering, Northwestern University; E. O. Neubauer (M '44), transmission engineer, Illinois Bell Telephone Co.; Dr. J. D. Ryder (F '51), dean, school of engineering, Michigan State University; Dr. E. H. Schulz (F '50), assistant director, Armour Research Foundation; Dr. R. M. Soria (M '49), vice-president, Amphenol Electronics Corp.; W. O. Swinyard, vice-president, Hazeltine Research, Inc.; O. I. Thompson, vice-president, DeVry Technical Institute; and W. C. White (F '47), retired from General Electric Company.

The recognition dinner is a prelude to the annual NEC exposition which is expected to attract 10,000 to Chicago next October, Mr. Enenbach said.

NEC is sponsored by the AIEE, Illinois Institute of Technology, Institute of Radio Engineers, and Illinois and Northwestern Universities. Participants are: Michigan, Michigan State, Notre Dame, Purdue, Wayne State, and Wisconsin Universities, Electronic Industries Association, and the Society of Motion Picture and Television Engineers.

AIEE Louisville Section

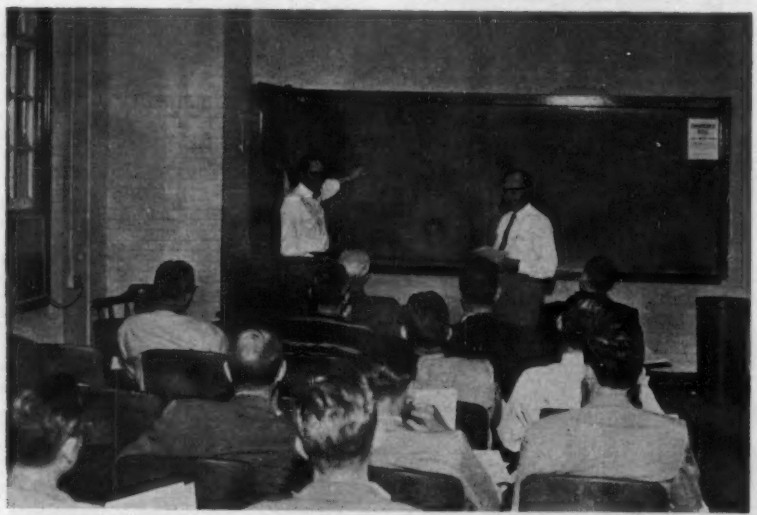


Photo by Al Hisenbaugh

A REFRESHER COURSE to prepare for the Kentucky Professional Engineering License examination was sponsored recently by the Louisville Section of the Institute. Chairman of the Technical Discussion Committee, J. J. Jennings, served as director of the course and prepared or secured all the literature and other material used. Several members of AIEE served as discussion leaders of subjects in their particular field. Plans are being made to repeat the course in the fall. During the engineering economics session (above), Mr. Jennings is shown at the blackboard and T. W. Talcott, past chairman and guest instructor, discusses a formula.

Plans Announced for Fifth Nuclear Congress

Preliminary plans for the Fifth Nuclear Congress to be held in Cleveland, Ohio, in April 1959, were announced recently by Engineers Joint Council (EJC). At the same time, engineers and scientists who would like to present technical papers during the Congress were invited to submit outlines before October 1, 1958.

As in the past, the Congress will be composed of four parts: The Nuclear Engineering and Science Conference, the Hot Laboratories and Equipment Conference, the Atomic Energy Management Conference, and the Atomfair, at which nuclear equipment will be on display. The Congress will be held at the Cleveland Auditorium, April 5-10.

Clarke Williams of Brookhaven National Laboratory, chairman of the Nuclear Engineering and Science Conference, announced that papers will be considered for inclusion in the 1959 program if summaries are submitted before October 1, 1958. He stated that prospective authors should submit 300 to 500 word summaries of proposed papers to the secretary of any one of the sponsoring societies. Final manuscripts are due November 28, 1958. A list of sponsoring groups is available from EJC, 29 W. 39th St., New York 18, N. Y.

Mr. Williams added that papers selected will be those presenting the most recent and outstanding developments in the nuclear field. Topics in the past have included reactor design, power plants, radiation techniques, instrumentation, shielding, waste disposal, and related items.

The sponsoring organizations are: AIEE, American Chemical Society, American Institute of Chemical Engineers, American Institute of Consulting Engineers, American Institute of Industrial Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, American Nuclear Society, The American Public Health Association, American Rocket Society, American Society of Agricultural Engineers, American Society of Civil Engineers, American Society for Engineering Education, American Society of Heating and Air-Conditioning Engineers, American Society of Mechanical Engineers, American Society for Testing Materials, American Water Works Association, American Welding Society, Atomic Industrial Forum, The Engineering Institute of Canada, Federation of Sewage and Industrial Wastes Association, Health Physics Society, Hot Laboratory Committee, Institute of Aeronautical Sciences, Institute of Radio Engineers, Instrument Society of America, National Industrial Conference Board, Society of American Military Engineers, Society of Automotive Engineers, Society of Naval Architects and Marine Engineers.

The Nuclear Engineering and Science Conference, on behalf of more than 25 sponsoring engineering and scientific

societies, will present technical papers on the latest developments in the fields of atomic energy applications for peaceful purposes. For information contact: T. A. Marshall, Jr. (manager, 1959 Nuclear Congress), or L. K. Wheelock (assistant manager), c/o EJC, 29 W. 39th St., New York 18, N.Y. PEnnsylvania 6-9220

Atomic Energy Management Conference, sponsored jointly by the Atomic Industrial Forum (AIF) and the National Industrial Conference Board (NICB), will present information that management wants to know on nuclear developments. For information contact: Charles Robbins, AIF, 3 E. 54th St., New York 22, N.Y. PLaza 4-1075, or E. A. Hammesfahr, NICB, 460 Park Ave., New York, N.Y., PLaza 9-0900.

Hot Laboratories and Equipment Conference, sponsored and conducted by the Hot Laboratory Committee, will deal with the highly technical details of the development of equipment and operation of laboratories for atomic energy. For information contact: Frank Ring, Jr., Oak Ridge National Laboratory, Oak Ridge, Tenn.

Atomfair, sponsored by the AIF, will be held in conjunction with the technical and management sessions of the Congress and will feature the latest developments in industrial uses of atomic energy. Registration is open to Congress delegates and to interested people in industry. Atomfair is managed by the International Atomic Exposition, Inc. For information contact: J. V. Friel, director, or H. F. Grebe, exhibits manager, 304 Architects Building, Philadelphia 3, Pa., RIttenhouse 6-5156.

International Conference on Information Processing

Key professional engineering societies and computer activities will be represented in the management of the United States delegation to the First International Conference on Information Processing (ICIP), sponsored by UNESCO (United Nations Educational, Scientific, and Cultural Organization) in Europe next year. A four-man team has been named to comprise the United States Committee for the ICIP, it was announced by I. L. Auerbach, chairman of the group. One of the objectives of the Committee will be to ensure outstanding evidence of American technological competence in the course of this country's participation in the UNESCO event, scheduled for Paris or Rome in June 1959.

The members will represent such engineering societies as AIEE, Institute of Radio Engineers, and the Association for Computing Machinery to the U. S. Committee; will act as co-ordinators for the United States delegation's participation in the conferences, symposiums, and exhibits; and will function as consultants to UNESCO on certain aspects of the international conference.

I. L. Auerbach, president of Auerbach Electronics Corporation, Narbeth, Pa., is chairman of the United States Committee for ICIP. Other members are: Dr. A. S. Householder, director of the Mathematics

AIEE Vice-President Visits Idaho Section

Courtesy C. B. Brown

M. M. ELWELL, vice-president of the AIEE Northwest District, spoke at the "ladies' night" meeting of the Idaho Section in Boise, May 14, during a tour of some of the eastern Sections of the District. Mr. Ewell discussed progress in the AIEE and in the electrical engineering profession. New officers of the Southern Idaho Subsection were introduced. Shown are: (*seated, left to right*) Mr. Ewell; Paul Worthen, retiring Section chairman; Bruce Mitchell, new subsection chairman; (*standing, left to right*) Gordon Hannum, new Subsection secretary-treasurer; Robert Ashenbrenner, Donald Russell, and Hal Christensen, members at large of the new Subsection executive committee. Not shown is Arthur Brown, new Subsection vice-chairman. Mr. Mitchell and Mr. Hannum are also, respectively, vice-chairman and treasurer of the Idaho Section for the coming year.

Materials Handling Conference

Courtesy Associated Photographers

CONGRATULATING A. C. Monteith, past president of AIEE and Westinghouse Electric Corporation vice-president, on his talk before 300 engineers attending a two-day Materials Handling Conference at the Penn-Sheraton Hotel, Pittsburgh, Pa., are top representatives of the sponsoring bodies. The group includes (*left to right*) R. N. Wagner, Aluminum Company of America, chairman of the Pittsburgh Section of the AIEE; E. M. Hays, Dravo Corporation, Conference chairman; Mr. Monteith; and S. Rifkin, General Electric Company, national chairman of the AIEE Materials Handling Subcommittee. The Conference was May 19-20, 1958.

Panel at the Oak Ridge National Laboratory; Dr. S. N. Alexander, chief of the Data Processing Systems Division of the National Bureau of Standards; and Evan Herbert, data control editor of *Automatic Control* Magazine.

Motor Protection, Stray Load Loss Tests, and Insulation Studied

According to R. C. Moore, chairman, the Induction Machinery Committee is continuing co-operation with the AIEE Relay Committee in studying problems relating to motor protection. The co-operation in the activity provides, from the subcommittee, consultation on and interpretation of motor design and general performance analysis. An additional contribution from the subcommittee is being made by a manufacturer–user combination to obtain specific tests on a motor being built for the user. It is expected that the test data will provide factual information to assist in the evaluation of motor thermal characteristics. The results will be helpful in the study of motor protection.

A stray load loss working group is actively proceeding with a test program. This group was appointed to investigate the accuracy and limitations of the present method of stray load loss determination as given in the Standards. The accuracy of the present method had been questioned for certain types of machine design. Several induction motors of various speeds and ratings have been tested so that the test program is well along toward completion. Data secured from these tests are being studied and analyzed. From the results, it is expected that recommendations will be made for suitable tests which might replace or supplement the reverse rotation method if found to be inadequate.

A group within the committee is studying temperature considerations relating to Class B and Class H insulated machines. The reason for the activity in this particular field is that interest has been shown in the loading characteristics with attendant effects on breakdown torque, efficiencies, power factors, and other characteristics when machines might be operated to full hot-spot capability in widely variant ambient temperatures.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry,* and *Power Apparatus and Systems,* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. Members may receive one subscription to any *one* of the bimonthlies for $2.50. The balance of the annual $5.00 subscription price will be paid by application of his annual dues for the year of the subscription. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional member subscriptions will be at the rate of $5.00. Nonmembers may subscribe on an advance annual subscription basis of $8.00 each (plus 50¢ extra for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.50 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Additional District Papers Are Now Available

The following is a list of District papers presented at the 1958 AIEE Southwest District Meeting, Middle Eastern District Meeting, Great Lakes District Meeting, and East Central District Meeting which were not numbered at the time of the meetings. They have now been numbered and are available to members for 40¢ each and to nonmembers for 80¢ each. Send order and remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y.

AIEE Southwest District Meeting, March 31-April 2, 1958

DP58-451 Progress in Station Class and Intermediate Class Lightning Arresters. *E. J. Allen*
453 Should Fault Current on Distribution Lines Be Limited? *G. G. Auer, R. W. Swarthout*
455 Application of BS&W Monitor in the Petroleum Industry. *K. T. Ball*
457 Guard and Testing Circuit Channel. *W. J. Benton*
458 Comparative Economics of New Light Sources in Industrial Applications. *R. D. Bradley*
459 Single-Phase Motors Now Cause Less Flicker in Residences than Three-Phase. *B. Brady*
460 Comparison of Modern Industrial Distribution Transformers. *F. J. Brütt*
462 Consideration for Remote Data Logging. *W. F. Cruess*
463 Microwave Station Emergency Power. *W. E. Freese*
465 Determining Actual Power Output and Derating Factor of Electric Motors that Drive Oil Well Pumping Units. *M. Halderson*
466 Some Basic Design Considerations for Refinery Electric Power Distribution Systems. *H. O. Hodson, G. Dupree*
468 Pump Turbine Application in Northeast Oklahoma. *D. K. Holway*
470 Narrow Base Steel Towers for Transmission Lines on City Streets. *H. C. Hughes*
471 Automation and Education. *W. B. Jarzembski*
477 Electrical Installations in a Modern Cement Plant. *D. LeClair*
479 High Temperature Construction Materials for Aircraft Electrical Systems. *K. D. McIlvaine*
480 Modern Use of Reclosers. *F. McStay*
482 Over-all Economics Dictates Single-Phase Residential Utilization. *B. Mohr, E. Buettner, B. Brady*
483 Purchased Electrical Power for the Refinery. *J. Mostrom*
485 Motor Operation and Protection on Unbalanced Voltages. *R. S. Reed, G. W. Cunningham*
486 Design Considerations for the *C-132* Electrical Power Systems. *R. J. Robinson*
488 Requirements for Successful Applications of Data Systems to Processes. *H. S. Stover*
DP58-489 Southwestern Public Service Company's Use of Digital Computers in Generation Scheduling. *R. W. Thomas, J. R. Wilson*
490 Notes on System Planning. *J. Wallis*
491 Aircraft Systems Design for Commercial Airline Maintenance. *J. R. Whitlock*
492 Wood Structures for 230-Kv and 345-Kv Construction. *R. G. York*

AIEE Middle Eastern District Meeting, April 28-30, 1958

DP58-599 Department of Agriculture Electric Power Supply for 12,000 Tons of Refrigeration. *J. D. Brooks, R. Siegel*
603 Objectives and Progress of the AIEE Insulation Evaluation Program. *P. L. Alger*
606 The Navy's Mobile Power Reserve. *J. W. Bishop*
608 Role of the Corps of Engineers, U. S. Army, in the Field of Hydroelectric Power. *R. M. Bush*
609 Large Downtown Substation. *M. L. Byrne*
610 The Present State and Anticipated Progress in the Field of Dielectric Materials. *T. D. Callinan*
612 The Bureau of Reclamation's Contribution to Electric Power Generation in the United States. *D. S. Campbell*
614 Measuring and Comparing the Reliability of Distribution Systems. *H. W. Dannatell*
616 Control of Nuclear Reactors. *E. P. Epler*
619 Initial 110-Kv Cable Installation in Baltimore. *C. S. Fiske, J. W. Gore, Jr., G. V. Bresnick*
624 Problems in Providing Service to Large Buildings. *O. R. Hamilton*
625 Economic Aspects of Safe Reactor Designs. *O. G. Hanson*
629 Surveys of Televison Reception at VHF and UHF. *W. L. Hughes*
630 A Time Compressed Single Sideband System. *M. I. Jacob, J. Mattern*
633 Progress Report on Proposed Test Code for Evaluation of Systems of Insulating Materials for Specialty Transformers. *L. W. Kirkwood*
635 Wind Inducted Vibration on Telephone and Distribution Conductor. *A. A. Lee, R. Ballard, R. R. Bouche*
637 Management of Research Laboratories. *T. M. Linville*
639 The Selection of Electrical Equipment for Constant Elapsed Life. *A. F. Lunkens*
640 Progress in the Evaluation of Form Wound Coil Insulation Systems. *G. L. Moses*
641 Transistors and Magnetic Cores Provide Memory Circuits for Time Division Multiplex System. *J. C. Myrick, L. W. Mader*
642 Financing Rural Electrification System—A Study in Management. *J. E. O'Brien, R. D. Partridge, R. H. Robinson*
643 Progress in the Evaluation of Random Windings and Field Coils in Accordance with AIEE No. *510. W. P. Penn*
650 Providing Illumination along the New Super Highways. *W. E. Schwanhausser*
652 69-Kv Pipe Cable Installation. *L. H. Spangler*
653 Perarylated Silanes—The Solution to the Problem of Radiation and Heat-Stable Organic Materials. *L. Spialter*
654 PAR-Penn Advanced Reactor Single Region Slurry System. *S. Townsend*
655 The Impact of the Spiral Antenna and Its Derivatives on the Design of Antennas and the Weapon System. *E. M. Turner*
656 Time Division Multiplex System. *S. Wald*
657 Insulation Applied to Ship-

board Electrical Equipment. *H. P. Walker*

DP58-658 Lighting and Power Problems Encountered in the Design of the Old Age and Survivors Insurance Building, Baltimore, Md. *N. S. Weiss*

AIEE Great Lakes District Meeting, May 5-7, 1958

DP58-659 Modular Structural Member Design for Substations. *R. C. Adler, J. T. Henderson, J. M. Waters*

660 Public Air-Ground Telephone Service Trial. *L. M. Augustus*

661 Application of Practical Optics for Auto Lighting. *P. J. Blinkild*

662 Placement of Lightning Arresters in Substations. *D. Burk, A. H. Knable*

663 Determination of the Optimum Transmission Voltage, 345 Kv versus 138 Kv. *R. D. Canburn, R. L. Stafford*

664 Telephone Special Services in Metropolitan Area. *E. C. Carlson*

666 Application of 46-Kv Reclosers. *C. R. French*

668 Florida-Cuba Over-the-Horizon System. *M. C. Gehring*

669 A System for the Production of a Pulsating X-ray Beam. *A. J. Gioia*

670 Induction and Dielectric Heating. *C. F. Hauri*

671 Qualitative Description of Inertial Guidance Principles. *W. H. Holl, B. P. Miller, C. F. Vondra*

672 Instrumentation Adequate To Insure Health and Safety Around a Power Reactor. *G. H. Whipple*

673 A Communication System for the AAOC. *H. I. Ingram*

674 The Electric Power Industry's Stake in Engineering Education. *J. S. Johnson*

675 Operation of ON over K Carrier. *J. W. Korte*

677 Can an Electric Power Company Afford a College-Trained Engineer? *J. H. Lampe*

679 Polyphase Motor Selection for Duty Cycle Applications. *G. C. Morris*

680 Design Considerations for Surface Measuring Equipment. *K. R. Morris*

683 What Is the Engineer's Horizon in the Electric Power Business? *G. A. Porter*

684 The Calculation of the Electric Field Energy of Moving Charged Particles. *R. J. Reid*

685 D-C Current Regulation of Rectifiers for Chlorine Plants. *C. Retting, J. P. Smith, J. S. Marr*

686 Nuclear Instrumentation for Reactors. *C. W. Ricker, W. Kerr*

687 General Aspects of Railroad Communications. *L. J. Ritter*

690 Consumers Power Probes 345 Kv. *H. F. Small, J. M. Brager*

691 The Design of a Pile Oscillator for the Ford Nuclear Reactor. *J. T. Stone, W. Kerr*

693 Auxiliary Power Design Considerations for a Nucler Power Plant. *S. Tjepkema*

AIEE East Central District Meeting, May 13-15, 1958

DP58-718 Solving Voltage Problems in Industrial Plants. *B. G. Bailey*

719 Some Features of Data Transmission. *R. M. Beer*

720 Why Consider A-C Mining Underground. *R. C. Berger*

721 An Evaluation of Safety Performance. *W. H. Brady, Jr.*

723 National and State Electrical Requirements for A-C Mining. *C. Brown, L. H. Harrison*

724 Selection of A-C Motors by Torque Requirements. *C. H. Buchanan*

725 Load Switching's Future—Unlimited. *J. B. Castle*

727 Arrestor Standards and Development—Their Mutual Effect in Providing Lightning Protection. *G. W. Cooper*

DP58-729 Techniques of the Application of Mercury Lighting in Industrial Areas. *C. M. Crysler*

730 Accelerated Testing of Mining Machine Cable. *W. G. Dahlstrom, A. L. Duna*

731 A Reverse Application of Storage Type Telemetering. *E. W. Dennis*

733 Reversing Electronic Drive for Automatic Feed Applications. *B. B. Finigan*

736 Application of Digital Computers to Cooling Tower Problems. *R. W. Gausmann*

737 Economic Load Dispatching with Computers. *R. E. Gilbreath*

739 Some Aspects of Safety in the Use of Electrical Equipment in Coal Mines. *L. H. Harrison*

740 Underground Lighting, Today and Tomorrow. *R. E. Havener, D. A. Green*

741 Telemetering KWH for Use in Tie-Line Road Regulation. *A. L. Hayley, Jr.*

744 Cathodic Protection of Underground Structures. *B. Husock*

745 Application of Super-Hi Lamps and High Frequency to Interior Lighting. *W. H. Johnson*

748 Bus Plus Supplementary Regulation Offers Economics over Individual Feeder Regulation. *H. E. Lokay*

DP58-749 Dielecric Heating-Progress in Profits through Losses. *C. R. Looper*

750 Selection and Application of Motors in Industry—Chemical, Mining, and Standard Motors. *R. G. Marsh*

751 Application of Distribution Overcurrent Protection on AG&E System. *T. J. Meier*

753 Operation of A-C Mines. *W. Painter*

754 Power Supply for Automatic Processing—The Voltage Dip Problem. *C. E. Quick*

757 Operation of an A-C Mine. *C. L. Sarff*

759 Power Sources for Induction Heating. *C. F. Schwan, A. J. Humphrey*

761 Aluminum vs Copper for Industrial Cable Applications. *J. W. St. Andre, H. Esch*

762 Silicone Insulation for Mine Motors. *L. A. Teichthesen*

763 A PBX Telephone Switchboard for Dispatching Service. *F. W. Treptow*

765 Switching Motors with Capacitors. *G. W. Walsh*

766 Today's Industrial Telemetering Systems. *H. Wittenberg*

767 Motor Bearings and Lubrication. *J. E. Youch*

AIEE FELLOWS ELECTED

Board of Directors Meeting, April 30, 1958

Pierre J. Ailleret (M '46), Directeur Général des Etudes et Recherches, Electricité de France, Paris, France, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to planning, execution, and interconnection of a nationwide electric system." Mr. Ailleret was born in Vienne en Arthies, Seine at Oise, France, on March 10, 1900. He graduated from Ecole Polytechnique in 1920, Ecole des ponts et Chaussées in 1924, and Ecole des Ponts et Chaussées in 1924, and Before World War II, Mr. Ailleret was active in the field of electric systems in public service companies, including the construction of the first 220-kv lines between the Alps and Paris, and of hydroelectric stations with seasonal storage in the Alps. Since the creation of Eletricité de France in 1946, he has been in charge of research and development in that organization. Mr. Ailleret has been a member of the French Atomic Energy Committee since 1951. He is past chairman of the Société Francaise des Electriciens, 1948; past chairman of the Electricity Committee of the Economic Commission for Europe, 1949-51; and past chairman of the Société des Ingénieurs Civils de France, 1957. He has been serving as president of the French Electrotechnical Committee since 1942. He is also a member of the Institution of Electrical Engineers (British) and president of the French National Committee of CIGRE (International Conference on Large Electric High Tension Systems). Mr. Aillert is the author of numerous technical papers on high-voltage transmission, long-range energy supply problems, and system planning. He has received many honors including: Médaille Blondel, 1940; Médaille Axel Axelson Johnson de l'Académie des Sciences Techniques de Suède, 1955; Lauréat de l'Académie des Sciences, 1956; and Officer de la Légion d'Honneur.

P. J. Ailleret

Thomas Everett Browne, Jr. (AM '36, M '45), manager, Research and Insulation Section, switchgear long-range major development department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for research contributions to rapid arc quenching for high-voltage circuit interrupters." Mr. Browne was born near Murfreesboro, N. C., on June 30, 1908. He received the B.S. degree in E. E. from North Carolina State College in 1928, following which he entered the Westinghouse Graduate Student Course. In 1929, he was assigned to a section in the materials and processes engineering department which was shortly

T. E. Browne, Jr.

F. M. Cahen

H. F. Dart

transferred to the Research Laboratories. As a research engineer, he conducted fundamental studies of arc phenomena in circuit breakers under the direction of Dr. Joseph Slepian. He received his M. S. degree in E.E. from the University of Pittsburgh in 1933. He served as a graduate assistant in the electrical engineering department at California Institute of Technology from 1933 to 1936, at the end of which period he received the Ph.D. degree (*magna cum laude*) in E.E. from Cal Tech. He then returned to Westinghouse Research Laboratories to resume studies of arc phenomena in flowing liquids and gases. He transferred to the power circuit breaker department in 1952 as supervising engineer in charge of advanced development and basic research. In 1954, he was appointed supervisor of the Research and Insulation Section in the switchgear long range major development department. He was appointed section manager in 1957. Mr. Browne is a member of the Pittsburgh Physical Society, Tau Beta Pi, Phi Kappa Phi, and Sigma Xi. He is a registered professional engineer in Pennsylvania and a Westinghouse lecturer in the electrical engineering department of the University of Pittsburgh. He is the author or co-author of 14 technical papers and the holder of 13 U. S. patents.

François Michel Cahen (M '48), Contrôleur Général à la Direction des Etudes et Recherches, Electricité de France, Paris, France, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to stable, secured operations of an extrahigh-voltage continental interconnected system." Mr. Cahen was born in Pantin (Seine), France, on February 17, 1894. He graduated as an engineer from Ecole Polytechnic (1919) and Ecole des Mines (1921) of Paris. He began his career as an engineer in the electrical department of the Société Général d'Entreprises in Paris. From 1930 to 1946, he was with the Société Général de Constructions Electriques et Mécaniques ALSTHOM, Paris, first as an engineer in the office for the studies of larger systems, then as chief of this office. During these years, he also acted as consulting engineer for the Union d'Electricité and several other electric power production and distribution concerns. In 1946, when Electricité de France was created, he was appointed head of the System Study Division of the Direction des Etudes et Recherches of this organization. In 1950, he was appointed directeur-adjoint of this department, and, in 1957, Contrôleur Général in charge of the co-ordination and control of the activities of all the electrical study and research divisions. Since 1939, Mr. Cahen has been the professor of electrical engineering at the Ecole Supérieure d'Electricité at Malakoff, Seine. He is member laureate and a former president of the Société Française des Electriciens, a member of the Institution of Electrical Engineers, and doctor *honoris causa* of the Ecole Polytechnique of the University of Lausanne, Switzerland. He is the author or coauthor of numerous papers published in the French and foreign technical publications, as well as of many reports presented at the meetings of learned societies and at international congresses; in particular, at the International Conference on Large Electric High Tension Systems (CIGRE).

Harry F. Dart (AM '20, M '26), patent engineer, Westinghouse Electric Corporation, Elmira, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions in the research and development of electron tubes." Mr. Dart was born near Forrest, Ill., on October 20, 1895. He received a B. S. degree in E. E. in 1917 and an E. E. degree in 1923, both from Purdue University. In 1917, he joined the Western Electric Company, Chicago, Ill., as cable development engineer. While with the Western Electric Company, he volunteered and received his commission in the Signal Corps. In 1919, he organized the first course on radio for the International Correspondence School, and published a radio handbook. After teaching at Rice Institute and Harvard Engineering School, he joined Westinghouse in 1922 as a radio tube engineer. He has held several design and supervisory assignments pertaining to all types of electron tubes. In 1952, he transferred to the newly formed Electronic Tube Division in Elmira, N. Y., where he is now patent engineer for the division. Mr. Dart's name first appeared in "Who's Who in Engineering" in 1922 and in "Who's Who in the East" in 1940. He is a senior member of the Institute of Radio Engineers and was a regional director in 1951 and 1952. He is a registered professional engineer in the States of New Jersey and New York. Mr. Dart has published several booklets and technical papers on electron tubes. For the past few years, he has been a member of the Executive Committee of the Ithaca Section of the AIEE. Mr. Dart has been active on the Electronics Committee of the Institute (1948-49, 1955-58). He has served as chairman of the Papers Review Subcommittee and Prize Papers and Awards Subcommittee of the Electronics Committee.

Wayne Curtis Hall (M '46), associate director of research for nucleonics, U. S. Naval Research Laboratory (NRL), Washington, D. C., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to administration of productive research and specifically to control of electrostatic interference with aviation communications." Dr. Hall was born in Reading, Kans., on July 29, 1909. He was educated at the University of Kansas where he received a B.S. degree in E.E. in 1931, an M.S. degree in physics in 1933, and a Ph.D. in physics in 1936. In 1935, he was employed by the NRL for research on the use of fuel cells to effect direct conversion of heat energy. From 1935 to 1945, he performed additional research on energy conversion, on electronic strain gages, on torsion meters, and on the aircraft precipitation static problem. In 1945, he became assistant head of the Aircraft Electricity Division, and, shortly thereafter, became superintendent of the Electricity Division. There he was in charge of research and develoment on electrical power systems for aircraft, basic research in electricity and magnetism, and basic research in solid-state physics and physical phenomena at ultra-low temperature. In 1946, he re-

W. C. Hall

ceived from the Navy Department a Distinguished Civilian Service Award ". . . for distinguished achievements in research on mitigation of precipitation static interference encountered by aircraft flying in adverse weather conditions." From 1949 through 1951, he was scientific officer at NRL in charge of a project for the Los Angeles Scientific Laboratory involving diagnostic measurements in the atomic weapons program. In 1954, he became superintendent of the Solid State Division at NRL, and, in July of that year, he was appointed associate director of research for nucleonics. Dr. Hall is a member of the American Physical Society, Sigma XI, Tau Beta Pi, and the Washington Academy of Sciences. He is the author of several technical papers and has been granted a number of patents. Dr. Hall served on the AIEE Basic Sciences Committee (1948-50).

James Hayward Harlow (M '43), chief mechanical engineer, Philadelphia Electric Company, Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for notable contributions to improvement in economy of electric power generation." Mr. Harlow was born on October 1, 1901, in Pittsburgh, Pa. He received his B.S. degree in E.E. in 1923 and his E.E. degree in 1933 from the University of Maryland. Upon graduation in 1923, he joined the Philadelphia Electric Company as cadet engineer. From 1925 until 1944, he was employed in the station operating department of the company in various capacities from assistant test engineer to assistant superintendent of station economy, in which positions he was responsible for results work, the development of system and interconnection operating procedures, and for representing the station operating department's interest, both mechanical and electrical in the design of a number of steam turbogenerator units. In 1944, he was made assistant chief mechanical engineer, and in 1948, chief mechanical engineer, in which positions he has been responsible for the steam power plant engineering, steam heat and gas engineering, industrial engineering, and civil engineering activities of the company. Mr. Harlow is a member of Tau Beta Pi, Phi Kappa Phi, Engineers' Club of Philadelphia, Franklin Institute, American Society of Mechanical Engineers, American Society for Testing Materials, and the National Society of Professional Engineers. He is a member of the Recognition Committee of Engineers' Council for Professional Development, the Committee on Power Generation of the Association of Edison Illuminating Companies, and the Boiler Code Committee of the American Society of Mechanical Engineers. He is a registered professional engineer in Pennsylvania, Maryland, and New Jersey.

Edgar Laroe Kanouse (AM '38, M '46), engineer in charge of design and construction, Department of Water and Power, City of Los Angeles, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the art of high voltage power transmission." Dr. Kanouse was born in Amarillo, Texas, on August 23, 1910. He graduated from the University of Oklahoma in 1932 with the degree of B.S. in E.E. He did postgraduate work at the California Institute of Technology where he received a masters degree, and at Stanford University where he received his Ph.D. degree in 1941. He was the holder of the Harris J. Ryan High Voltage Research Fellowship at Stanford and his work for the doctorate was on corona problems associated with extrahigh-voltage transmission. For over 20 years, Dr. Kanouse has been employed by the Department of Water and Power of the City of Los Angeles, where he has held a number of positions, including transmission system engineer, engineer of transmission and distribution design, and, at present, engineer in charge of design and construction. Dr. Kanouse is the author or coauthor of a number of technical papers on system planning and on transmission line design. He is a member of the AIEE Transmission and Distribution Committee (1949-58) and chairman of the Towers, Poles, and Conductors Subcommittee. He is chairman of the ASA Subcommittee C2 on Voltage Classifications and Clearances, which is doing work in connection with the proposed partial revision of the National Electric Safety Code. He is also vice-chairman of the AIEE Los Angeles Section Power Division for 1957-58. Dr. Kanouse is American adviser on problems of towers and tower foundations for CIGRE (International Conference on Large Electric Systems). He is a member of Sigma Xi, Sigma Tau, and the Los Angeles Electric Club.

Tom Cox Lloyd (AM '31, M '46), chief engineer, Robbin & Meyers, Inc., Springfield, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the art of electrical motor design." Mr. Lloyd was born in Emporium, Pa., on May 8, 1901. He received the B. S. degree in E. E. from Carnegie Institute of Technology in 1923. He served as instructor in electrical engineering at West Virginia University 1923-25; instructor at Ohio State University, 1925-29; lecturer at Antioch College, 1927-29, and associate professor of electrical engineering at Antioch, 1929-36. In 1936, he joined Robbins & Myers, Inc., as development engineer. He was named assistant chief engineer in 1938 and chief engineer in 1940. Following the initial work of Dr. Branson, Mr. Lloyd has devoted most of his technical interest to design synthesis, whereby, with the desired machine characteristics known, direct solution determines the machine construction. This synthesis as a design method is in direct contrast to the analysis on which most design texts depend. Mr. Lloyd is the author of numerous technical papers and the following books: "Electrical Equipment," 1930, John Wiley & Sons; and "Alternating Current Machines," John Wiley & Sons, first edition in collaberation with A. F. Puchstein 1936, second edition with A. F. Puchstein 1942, third edition with A. F. Puchstein and A. G. Conrad 1954. Mr. Lloyd is a member of Eta Kappa Nu, Sigma Xi, and Theta Xi. He has served on the AIEE Rotating Machinery Committee (1943-49, 1953-55) and Education Committee (1949-57).

Harry Able Lott (AM '37, M '46), manager, planning department, Southern California Edison Company, Los Angeles, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the planning and operation of a major power system and the operation of major power system interconnections." Mr. Lott was born in Warren, Ohio, on January 17, 1898. He received a bachelor's degree in E. E. from Ohio State University in 1921. During the years 1921 to 1924, he was principal of Kings Mills, Ohio, High School for one year and taught electrical subjects at McKinley High School at Canton, Ohio, for two years. From 1924 to 1926, he was employed by a Los Angeles firm of consulting engineers with utility assignments in Needles, Calif.; Nogales, Ariz.; and Culiacan, Sinaloa, Mexico. He joined Southern

J. H. Harlow

Gladser Studio

E. L. Kanouse

Cristof Studio

H. A. Lott

California Edison Company in April 1926 where his successive assignments were: substation operator, dispatcher, chief dispatcher, operating engineer, chief of Division of Electrial Engineering, chief of Division of System Planning, executive engineer, and, since February 1956, manager of planning department. In this position he has charge of co-ordinating all the company's long-range and short-range plans for expansion of the electrical system plus assignments relating to power interchange with other utilities. Mr. Lott is a member of the Pacific Coast Electrical Association, the Los Angeles Electric Club, the Edison Electric Institute Electric Power Survey Committee, and he is chairman of the Pacific Southwest Power Interchanging Committee. He is a registered professional engineer in the State of California. Mr. Lott has served as chairman of the Los Angeles Section of the Institute, 1957-58, and as a member of the AIEE System Engineering Committee, (1950-55).

Louis Meyerhoff (M '39), chief research engineer, General Cable Corporation, Bayonne, N. J., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of high-voltage cables." Mr. Meyerhoff was born in Poltaza, Russia, on December 8, 1896. He came to the United States at an early age, receiving practically all his formal schooling in the City of Baltimore. He was graduated from Johns Hopkins University with the degree of B. S., in engineering in 1917, and in 1924 received the L.L.B degree from the University of Maryland. In addition to some 30 years of activity in the high-voltage cable field, Mr. Meyerhoff has also taught electricity, taken charge of maintenance for three years and practiced law for six years. In the field of high-voltage cables, he has been associated exclusively with General Cable Corporation and its predecessor company, Standard Underground Cable Company. He has successively held the titles of research engineer, assistant director of research, associate director of research, director of research, and, since September 1957, chief research engineer. Mr. Meyerhoff's contributions embrace a wide range of subjects, including a-c resistance of cables, a-c resistance of pipe-cable systems, creep and fatigue characteristics of lead alloy cable sheaths, development of cable accessories, and development of insulations. He is presently active in the development of 345-kv cable in connection with an industry-sponsored project. Mr. Meyehoff is a member of Tau Beta Pi, American Physical Society, American Society for Testing Materials, American Association for the Advancement of Science, Institute of Metals (British), National Research Council Committee on Electrical Insualtion, and is listed in "American Men of Science" and "Who's Who in Engineering."

John Hutchins Neher (AM 24, M '38), senior engineer, Philadelphia Electric Company, Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to protective relay schemes and research on the thermal factors in underground power cables." Mr. Neher was born in Princeton, N. J., on August 14, 1899. He graduated from Princeton University, Phi Beta Kappa, in 1921 with a B.S. degree and received his E.E. degree at Princeton in 1923. After a year on the student course at Westinghouse, he was employed in the laboratories of the Philadelphia Electric Company, and, in 1926, he was employed in its engineering department, working on the design and development of relay protective systems. Mr. Neher holds five U.S. patents on relays and associated devices and is author or co-author of three papers on relays in AIEE *Transactions* and of four articles in the technical press. During World War II, he served in the Bureau of Ships in Washington, D.C., as officer in charge of the Radio Frequency Cable Section and chairman of the Army–Navy RF Cable Co-ordinating Committee; attaining the rank of Commander, USNR, in 1945. For his service, he was awarded the Secretary of the Navy's Commendation Ribbon. He returned to the Philadelphia Electric Company in 1946 in the Special Investigation and Testing Division and undertook a complete investigation and review of the fundamental theory underlying the various factors involved in determining the temperature rise of cable systems under both steady-state and transient loading. Mr. Neher is a special member of the AIEE Insulated Conductors Committee and the author or co-author of nine papers on cable heating problems. He received first prize in the AIEE Power Division in 1955 as co-author of the paper, "Power Distribution System Parameters." He served on the AIEE Protective Devices Committee (1937-42) and was chairman of the Relay Subcommittee (1937-40). Mr. Neher is a registered professional engineer in the State of Pennsylvania, a member of the Princeton Engineering Association, and of the Franklin Institute.

Elmer G. Norell (AM '28, M '46), partner and chief electrical engineer, Sargent & Lundy Engineers, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the advancement of large scale electrical power generation. Mr. Norell was born in Rockford, Ill., on December 8, 1902. He graduated from the University of Cincinnati in 1926 with the B.S. degree in E.E. Upon graduation, he accepted a position with Stone & Webster and, shortly thereafter, transferred to the engineering staff of the Solvay Process Company, working on the design of a steam-electric power plant at Solvay, N. Y. In 1928, he moved to Chicago and accepted a position with Sargent & Lundy as field electrical engineer in the construction of Powerton Power Station near Pekin, Ill. He returned to the Chicago offices of Sargent & Lundy in 1936 and successively held the positions of chief electrical draftsman, electrical engineer, and chief electrical engineer. His principal work has been the electrical design of steam-electric power stations and high-voltage substations. He was responsible for development and application of centralized control of the turbine generator, boiler, and power switching with a resultant reduction in the number of operators required. He also participated in the development of a reliable and more economical system for distributing auxiliary power and control cables in the power station. In 1951, he became a partner in Sargent & Lundy. Mr. Norell has served on the AIEE Protective Devices Committee (1947-58) and as chairman (1954-56). He has also been a member of the Power Generation Committee (1953-58) and Power Division (1954-56). He served successively as treasurer and secretary of the Chicago Section of the Institute, 1955-56, and became chairman of the Section in 1957. Mr. Norell is a member of Eta Kappa Nu, Western Society of Engineers, Illinois Society of Professional Engineers, and the Chicago Association of Consulting Engineers.

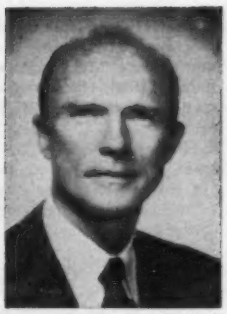
P. H. Robinson (AM '29, M '36), executive vice-president, Houston Lighting & Power Company, Houston, Texas, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to economical design and protection of an electric power system." Mr. Robinson was born in Woods County, Okla., on April 24, 1904. In 1925, following graduation from the University of Oklahoma with the B.S. degree in E.E., he entered the Westinghouse Electric Corporation's Student Engineering Training Course. Upon completion of the course, he was selected to work in the Central Station Division of the general engineering department of Westinghouse's East Pittsburgh (Pa.) plant. In August 1928, he was employed by the Houston Lighting & Power Company as transmission and relay engineer. In the early 1930's he collaborated with

Louis Meyerhoff

Courtesy Photo-Arts

J. H. Neher

E. G. Norell



Courtesy Roulande

P. H. Robinson

I. T. Monseth of Westinghouse in a series of articles on "Theory and Application of Relay Systems," published as a book by McGraw-Hill in 1935. This text has been widely used in the industry and was adopted by a number of technical colleges and universities for advanced electrical engineering courses. In 1936, Mr. Robinson transferred to the commercial department of the Houston Lighting & Power Company where he served successively as power sales engineer, assistant commercial superintendent, superintendent to commercial and industrial sales, and superintendent of industrial engineering. In May 1950, he was promoted to assistant vice-president and in 1951 to vice-president in charge of operations. He was named executive vice-president of the company in April 1958. Mr. Robinson is a registered professional engineer in the State of Texas and a member of the Texas Society of Professional Engineers. He is a member of Tau Beta Pi and Sigma Tau. He has been active in the Houston Section of the Institute, serving on numerous committees and as chairman of the Section, 1934-35. He served on the AIEE Protective Devices Committee (1939-40).

AIEE PERSONALITIES

J. H. Foote (AM '18, F '32), chief engineer and president of Commonwealth Associates, Inc., received an honorary doctor of science in engineering degree from Wayne State University, Detroit, Mich. Mr. Foote's citation read, ". . . a master of technical process and electrical power administration, he has earned the respect and admiration of his professional colleagues here and abroad; a citizen of lively conscience, he merits the warm appreciation of a grateful community." Mr. Foote has served as a director of the Institute (1954-56) and was named vice-president of AIEE District No. 5 in 1956. He has been a member of the following AIEE Committees: Power Transmission and Distribution (1929-31), Protective Devices (1932-34), Power Generation (1936-46), Domestic and Commercial Appliances (1940-41), Registration of Engineers (1946-58), Standards (1947-50), Insulated Conductors (1947-49), Safety (1954-57), Planning and Co-ordination (1954-56), and Edison Medal (1955-57).

G. R. Hadden (M '56), assistant vice-president, Consolidated Edison Company of New York, Inc., has been elected a vice-president of the company. **G. R. Milne** (AM '21, F '49, Member for Life), mechanical engineer of Consolidated Edison, has been named chief mechanical engineer. **C. W. Franklin** (M '24, F '44), electrical engineer, has been named chief electrical engineer of the company. Mr. Milne has been a member of the AIEE Power Transmission and Distribution Committee (1937-42) and Electrical Machinery Committee (1942-43). Mr. Franklin has served on the following Institute Committees: Power Transmission and Distribution (1933-37); Production and Application of Light (1935-37); Board of Examiners (1945-55, chairman 1952-54); Lamme Medal (1954-58, chairman 1956-57); and Professional Development and Recognition Department (1956-57).

C. E. Peck (AM '47, M '57), metallurgical process consultant, Westinghouse Electric Corporation, East Pittsburgh, Pa., has received the Trinks Award, highest honor of the industrial heating industry, for his development of controlled gas atmosphere systems and equipment for industrial furnaces. Mr. Peck is a member of the American Society of Metals, American Society of Mechanical Engineers, and Association of Iron and Steel Engineers. Mr. Peck has served on the AIEE Electric Heating Committee (1947-58).

Otis Howard (AM '36, M '38), manager of operations, Oklahoma Gas & Electric Co. (OG&E), has taken early retirement to go to Taiwan (Formosa) to help direct a power development program in that country for the J. G. White Engineering Corporation. Mr. Howard has been a member of the AIEE System Engineering Committee (1954-55). **R. F. Danner** (AM '29, F '45), manager of engineering and construction for OG&E, has been elected a vice-president and will be in charge of research and development. Mr. Danner has served as AIEE vice-president for District No. 7 (1946-48), as a director of the Institute (1951-55), and as a member of the following AIEE Committees: Power Transmission and Distribution (1940-42, 1943-45); Industrial Control Devices (1946-47); Technical Program (1947-48); Student Branches (1951-58); Registration of Engineers (1952-57); Power Division (1953-54); Planning and Co-ordination (1954-55); Petroleum Industry (1954-55); and Administration Department (1956-57). The positions formerly held by Mr. Howard and Mr. Danner have been eliminated and the department heads formerly reporting to these men will report to **C. W. Anthony** (AM '45, M '51), executive assistant—operations. Mr. Anthony is chairman of the Oklahoma City Section of the AIEE (1957-58).

E. W. Engstrom (F '49), senior executive vice-president, Radio Corporation of America, has received the Industrial Research Institute Medal for 1958. It was accompanied by the citation ". . . for distinguished leadership in industrial research . . . and for his correlation of research with engineering and commercial production to provide new electronic services to industry and the public." Mr. Engstrom served on the AIEE Lamme Medal Committee (1954-57) and is a member of the Hoover Medal Board of Award (1957-63).

J. M. Ide (M '53), technical director of the U.S. Navy Underwater Sound Laboratory, New London, Conn., recently received a career service award, one of 10 given annually within the federal service by the National Civil Service League. Dr. Ide was cited for "outstanding achievements in research, development, and organization" and "aiding materially in improving sonar and other underwater devices which are now essential to the successful operation of atomic-powered submarines."

Henri Busignies (M '56), president of Federal Telecommunication Laboratories, received the honorary degree of doctor of science at the commencement exercises of Newark College of Engineering, Newark, N. J. An authority in the fields of electronic direction finding equipment and air navigation, radar, and radio communications, Mr. Busignies is noted for having invented, in 1926, the first automatic direction finder for aircraft. He presently holds more than 100 patents in direction finding systems, instrument landing systems, and early radar design including Moving Target Indicator radar.

F. R. Kappel (M '43, '50), president of the American Telephone and Telegraph Company (AT&T), received the honorary degree of doctor of laws at Lehigh University's commencement exercises in Bethlehem, Pa. Mr. Kappel also delivered the principal address at the exercises. Mr. Kappel was named president of AT&T in September 1956 before which he had served as president of the Western Electric Company, a subsidiary.

E. H. Snyder (AM '27, F '49), vice-president in charge of electric operations, Public Service Electric and Gas Company,

Newark, N. J., has been elected president of the Lehigh University Alumni Association.

Morton Sultzer (AM '13, M '34, Member for Life), retired personnel planning director of the Bell Telephone Laboratories, New York, N. Y., received a Lehigh University alumni award for personal achievement and service.

W. B. Wigton (AM '40), chief engineer of the G&L and Hypro Division, Giddings & Lewis Machine Tool Company, Fond du Lac, Wis., has been named general manager of the Davis Boring Tool Division of the company. Mr. Wigton served on the AIEE General Industry Applications Committee (1947-49).

B. A. Wilson (AM '49), of the weapons system development laboratory, Hughes Aircraft Co., Tucson, Ariz., has joined Exide Industrial Division, The Electric Storage Battery Company, Philadelphia, Pa., in the new position of assistant to the missile products manager of the missile applications department.

H. W. Henkels (AM '53, M '57), advisory engineer, Westinghouse Electric Corporation, Youngwood, Pa., has been appointed manager of the advanced development engineering section of the Westinghouse semiconductor department at Youngwood. Mr. Henkels has served on the AIEE Metallic Rectifiers Committee (1955-58) and Solid-State Devices Committee (1957-58).

J. S. Tompkins (AM '30, M '48), assistant chief power engineer, Aluminum Company of America, Pittsburgh, Pa., has been named chief power engineer. Mr. Tompkins, who joined Alcoa in 1930, will give particular attention to the economical development of new sources of electric power, and will be responsible for engineering phases of the generation and transmission of power from future developments. Mr. Tompkins served on the AIEE Electronic Power Converters Committee (1947-49) and Chemical, Electrochemical, and Electrothermal Applications Committee (1947-51).

L. E. Barbrow (AM '42, M '48), chief of the Photometry and Colorimetry Section, Optics and Metrology Division, National Bureau of Standards, Washington, D. C., has received a meritorious service award from the U. S. Department of Commerce. Mr. Barbrow was cited for a major contribution to the establishment of photometric standards on a fundamental basis, and for outstanding service as administrator of research and testing projects in the fields of photometry and colorimetry. Mr. Barbrow has served on the AIEE Production and Application of Light Committee (1954-58).

D. A. Roberson (AM '44, M '51), supervisor of the Power Utilization Section, Electrical Branch, Aro, Inc., AEDC, Tullahoma, Tenn., has been appointed assistant manager of the Electrical Branch.

C. F. Kucera (M '46), assistant manager of the New York district office of Allis-Chalmers Manufacturing Company Industries Group, has been appointed manager. An electrical engineering graduate of Iowa State College, Mr. Kucera joined Allis-Chalmers in 1946. He served on the AIEE Substations Committee (1953-54).

Haroun Mahrous (AM '54, M '58), associate professor of electrical engineering, University of Illinois, has been appointed chairman of the electrical engineering department of the Engineering School, Pratt Institute, Brooklyn, N. Y.

N. A. Begovich (AM '44), director of the radar laboratories of the ground systems, Hughes Aircraft Company, has been appointed director of engineering of Hughes' Ground Systems Group in Fullerton, Calif. **W. T. Clary, Jr.** (AM '55), head of the Digital Subsystem Section, has been appointed head of the systems analysis department under Dr. Begovich.

OBITUARIES

John H. Trevitt (M '47), Development Section, Dictaphone Corporation, Bridgeport, Conn., died recently. Mr. Trevitt was born in Vienna, Austria, in 1899. He was a graduate in electrical engineering of Vienna University and started his career with the AEG Company in Vienna. Following this, he served for several years as assistant manager of two textile mills and then, in 1927, he joined the Dictaphone organization as Eastern European representative. He came to the United States in 1939, to serve in the Development Section of Dictaphone Corporation where he was active until his death. Mr. Trevitt held several patents on motors and motor control devices, which were designed particularly for dictating machines.

Albert M. Baehr (AM '40), electrical engineer, Baehr, Greenleaf & Associates, Lakewood, Ohio, died recently at the age of 63. Mr. Baehr graduated from Case Institute of Technology with a mechanical engineering degree in 1916. He served in the Army during World War I, after which he was engaged in postgraduate work at the University of London. During his career, he was associated with the Lakewood Engineering Company and the National Carbon Company. He established his own firm in 1930. Mr. Baehr was a lieutenant colonel in the air technical services command of the Army Air Corps during World War II. He was a member of the Illuminating Engineering Society and the National Society of Professional Engineers. He was active in the alumni affairs of Case Institute of Technology and was formerly a member of the board of trustees.

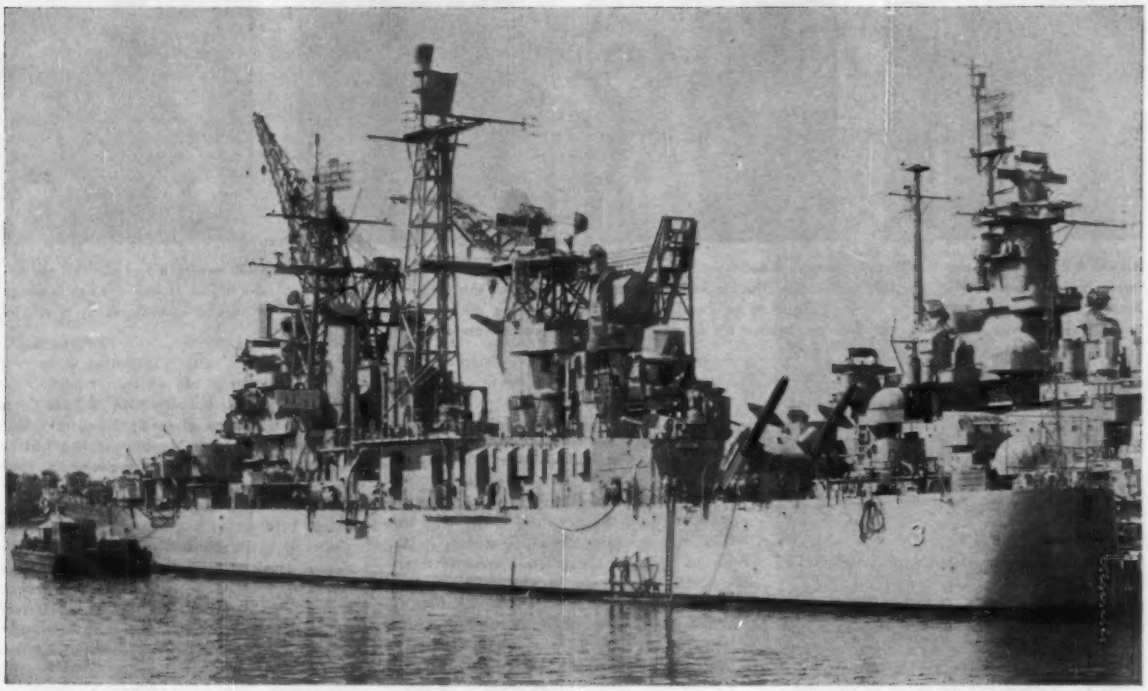
Charles Thomas Brown (M '55), chief engineer, Columbia-Southern Chemical Corporation, Corpus Christi, Texas, died recently at the age of 46. Mr. Brown attended Rice Institute for three years and received his engineering degree from Texas A&I College. He joined Columbia-Southern in 1933 and had been chief engineer for several years. He was a member of the Texas Society of Professional Engineers and the American Society of Mechanical Engineers.

William C. Dreyer (AM '40, M '47), district service manager, South Texas District, Westinghouse Electric Corporation, Houston, Texas, died recently at the age of 59. Mr. Dreyer was born in Boston, Mass., on April 10, 1898. After graduating from California Institute of Technology in 1924, he joined the Westinghouse Electric Corporation in the general engineering department at East Pittsburgh, Pa. After a short period in the St. Louis area, he transferred to Dallas, Texas, in 1936. He was promoted to district service supervisor in 1942 and transferred to the Houston office in 1946. He was made district service manager in 1953. For many years, Mr. Dreyer was active on the Planning Committee of the Power Distribution Conferences sponsored by the department of electrical engineering at the University of Texas. He was one of the organizers and served continuously on the Planning Committee of the Relay Conferences sponsored by the electrical engineering department of Texas A&M College. Mr. Dreyer was a registered professional engineer in the State of Texas and a member of the Houston Engineering and Scientific Society. He was an active member of the Houston Section of AIEE and helped to organize the first Petroleum Industry Conference held in Tulsa, Okla., in 1954. Mr. Dreyer served on the AIEE Chemical, Electrochemical, and Electrothermal Committee (1947-55).

Laurence A. Hawkins (AM '03, M '13, Member for Life), pioneer in research at the General Electric Research Laboratory, died recently. Dr. Hawkins received his A.B. degree from Williams College in 1897 and his B.S. degree from Massachusetts Institute of Technology in 1899. He received the honorary degree of doctor of science from Williams College in 1944. In July 1899, he went to work in the engineering and patent department of the Stanley Electric and Manufacturing Company. He joined the General Electric Company in 1903 as patent attorney, later transferring to the transportation engineering department and in 1912 to the research laboratory. He retired as executive engineer in 1945 but continued as a consultant until 1948. In his capacity as executive engineer, he served as business manager and co-ordinator of the research activities of the scientific staff. He was a member of Phi Beta Kappa, Sigma Xi, and many scientific organizations. Mr. Hawkins served on the AIEE Research Committee (1922-24, 1935-41) and Production and Application of Light Committee (1926-41).

Murray G. Graff (AM '22, M '32, Member for Life), retired electric utility sales engineer of the General Electric Company, died recently. Mr. Graff received his degree in electrical engineering from the Massachusetts Institute of Technology in 1916. He started to work for the General Electric Company in Denver, Colo., in 1929, and retired in 1954. Mr. Graff served on the AIEE Membership Committee (1941-43).

OF CURRENT INTEREST



▲ *USS GALVESTON (CLG-3)*, second ship of the U.S. Navy to be named for the Texas city, is the first such cruiser equipped with the deadly Bendix TALOS missile.

Missile-Age Cruiser Is Best Antiaircraft Arsenal Anywhere

THE FIRST of a new fleet of missile-age cruisers, described as capable of destroying enemy aircraft and surface targets at ranges in excess of 65 miles, was commissioned at the Philadelphia (Pa.) Naval Shipyard on May 28th.

Principal armament of this "missile cruiser," the *USS Galveston*, will be the deadly TALOS missile, made for the U.S. Navy by the missile section of the Bendix Aviation Corporation, Mishawaka, Ind. Effective against both air and surface targets, the TALOS is hailed by Adm. Arleigh Burke, USN, Chief of Naval Operations, as the "best (antiaircraft) missile in any arsenal in the world."

The *Galveston* will be the first of several cruisers to use the TALOS with its nuclear capability—including the first nuclear-powered cruiser, the *USS Long Beach*.

The deadly TALOS, named after the Greek demigod who guarded Crete, is powered by a ramjet engine 40,000 hp, giving it supersonic speed, a range far in excess of conventional Navy "big guns," and a ceiling higher than any bomber.

First Navy TALOS

The TALOS missile is accelerated by a solid-fuel rocket booster. On reaching cruising speed, the booster is jettisoned and the missile's ramjet engine takes over.

The rampjet is the simplest of all missile engines. At its high operating speed, it rams air into itself at the front end, burns this air with kerosene as the fuel, and ejects the superheated air at the rear. Thus, it develops its thrust in much the same fashion as does a jet—but without the complex air compressor turbine the jet requires.

Because of its simple construction, it requires only one sixth to one eighth of the fuel load that a rocket would need to develop the same power for the same length of time.

The missile is directed to the target area by a special guidance system using radars that combine many automatic functions. Because of exceptional power, the radars are able to pick up targets many miles beyond the horizon. Included in these systems for the missile ships are the *AN/SPG-49* radar antennas that resemble giant searchlights, *AN/SPW-2* missile guidance radars, and the *Mark 111* (one-eleven) computers that implement the function of target designation, acquisition, tracking, launcher control, missile control and display for rapid and accurate acquisition of a target by the TALOS. Sperry guidance and fire control engineers are assigned to the Philadelphia Naval Base to handle installation and checking of radar systems on guided missile ships.

When the missile approaches the target, a "homing brain" takes over, detonating the warhead with a proximity fuse as the TALOS reaches the target "kill" range.

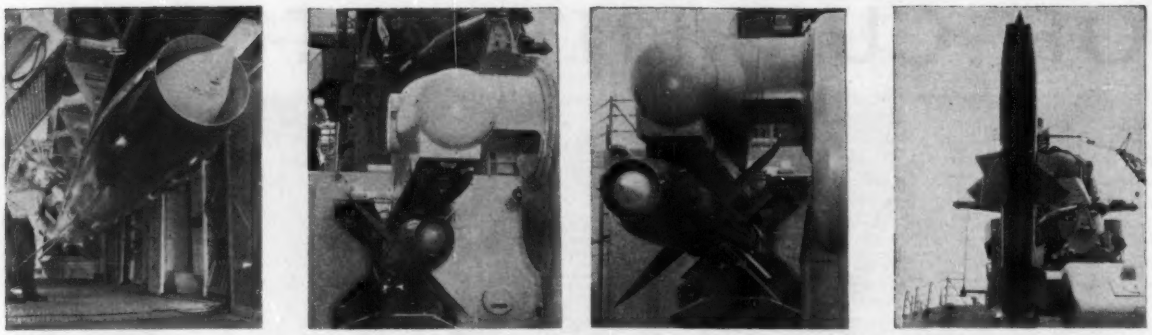
Missile Cruiser *Galveston*

The cruiser that carries this missile-age weapon that may revolutionize naval strategy and tactics is the second one named for the Texas city. The first *USS Galveston*, commissioned in 1905, served during World War I and several other special missions before it was finally scrapped in 1933.

The present *Galveston* was launched in 1945, placed in reserve status in 1947 when nearly ready for commissioning, and converted to a guided missile cruiser starting in 1956.

Bumblebee Program

The supersonic surface-to-air ramjet powered missile, which furnishes the principal armament for the ship, is a product of the Navy's once highly secret "Bumblebee Program" and represents 13 years of research and development by a group of



NAVY MISSILE MEN check a deadly Bendix TALOS missile *(left)* that forms major armament of the *USS Galveston*. The faster-than-a-bullet missile slides along track *(center left and right)* to be swung into position for long-range high-firepower defense against air attack. In firing position *(right)*, capabilities of the TALOS are said to raise the air defense of the United States Fleet to new highs. It has a 65-mile range and can destroy enemy aircraft at stratospheric altitudes by a special radar guidance system.

universities and industrial organizations to provide atomic-age weapons for the United States Fleet.

The program dates back to the closing months of World War II when the Navy Bureau of Ordnance requested Johns Hopkins University Applied Physics Laboratory (APL) at Silver Spring, Md., which had developed the proximity fuse for shells, to suggest a means of combatting the Japanese kamikaze menace. After several months' study, APL scientists advised the development of a supersonic ramjet propelled guided missile. The Bureau of Ordnance authorized the development and it was given the code name of Bumblebee. Why the name was chosen is not known, but of significance is the fact that in many APL offices and laboratories hangs the following:

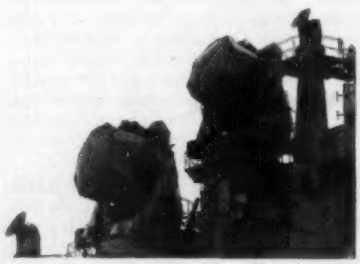
> "According to recognized aerotechnical tests, the bumblebee cannot fly because of the shape and weight of his body in relation to total wing area. But the bumblebee doesn't know this, so he goes ahead and flies anyway."

BATTLE STATION below decks on cruiser *Galveston* shows business end of Bendix TALOS missile that may ring up the curtain on what might be a revolutionary era in naval strategy.

Theory and Fact

The ramjet had been a theory in physics since 1913, but it had not been flown successfully. Nevertheless, APL scientists believed it held great promise as a supersonic engine. The difficulty had been that it would not operate efficiently unless it be boosted by some means to a velocity near the speed of sound. It was believed the solid-propellant rockets developed during WW II could provide the necessary boost.

On June 15, 1945, a ramjet fashioned from the 6-inch exhaust pipe of a Thunderbolt fighter-plane made a successful flight over the sand dunes of Island Beach, N. J., attaining a velocity of 1,200 miles per hour. In October 1945, another ramjet of the same size demonstrated thrust over aerodynamic drag. A replica of the "flying stovepipe," as it had been dubbed, has been given an honored place in the National Air Museum of the Smithsonian Institution as the world's first supersonic ramjet engine.



SUPER-RADARS developed and produced for the Navy by the Sperry Gyroscope Company will guide TALOS missiles launched from the guided missile cruiser *USS Galveston*.

In the developmental work on beam-riding and stability control, a test vehicle powered with a solid-propellant rocket engine proved so effective that it was recognized as having great possibilities as a prototype of a tactically useful short-range antiaircraft missile of relatively simple design. It was engineered and became the TERRIER missile now in service in the fleet on board the cruisers *USS Boston* and *Canberra* and the destroyer *USS Gyatt*.

In a program with such advanced objectives as those of TALOS, it is to be expected that many pioneering achievements will be made and such has been the case. Not only did the workers on this project make the first demonstration that the ramjet was a practical engine for propulsion of supersonic missiles, but also they made the first flights of fully controlled missiles powered by these engines, thus proving the reliability of the engine in numerous long-range flights. The TALOS booster set a new level in the size and performance of solid-fuel booster rockets. The TALOS was also the first missile to employ a dual guidance system with accuracy demonstrated repeatedly at short and long ranges. This program also pioneered the introduction of atomic warheads into antiaircraft missiles.

Under the sponsorship of the Bureau of Ordnance, a large number of organizations made substantial contributions to the development and engineering effort which has brought the TALOS to its present advanced state.

Lost Uninhabited World Soon To Have Steel Mill, Power Dam, and 100,000 People

AN INDUSTRIAL COMPLEX—including a steel mill and a hydroelectric dam and plant—are going up on the edge of Venezuela's "Lost World" (so named by Sir Arthur Conan Doyle), where humans are far rarer than jaguars and iguanas.

At the junction of the sluggish Orinoco and the mad-rushing Caroní rivers, the basic elements of heavy industry also converge: iron ore and hydroelectric power. By Autumn 1958 the first results of this combination will blossom forth in the

form of electric power from the massive waterfalls of the Caroní.

The first of a projected six generators at the new Macagua Dam will churn out power to be wired across the Caroní to a brand-new steel mill going up in the outskirts of Puerto Ordaz. Each of the turbine-powered generators will produce 50,000 kw of electricity. Two other dams are in the planning stage. The steel mill, which will occupy more than a square mile, eventually will produce 1.2 million tons of finished products annually, beginning in Fall 1958 with seamless tubing for the vast Venezuelan oil industry.

In a few years, the mill is expected to produce a variety of other products, such as structural rolled sections, rails, reinforcing rods, steel coils, galvanized and barbed wire, nails, and cast-iron ingots.

This gateway city, created by U.S. Steel Company's subsidiary, the Orinoco Mining Company, exists at present only to load the rich iron ore of Cerro Bolivar onto ocean-going ships. Soon Puerto Ordaz will have far greater reasons for being. Thanks to constantly dredged and redredged channels, the sluggish Orinoco River is navigable up to this point. The port area will be greatly enlarged. Cerro Bolivar, a mountain virtually made of iron ore, is 75 miles to the west. A railroad hauls the ore from there to this port on the south bank of the Orinoco.

Puerto Ordaz was built in 1952. Before then it was wilderness. This brand-new city has 10,000 people living in ultramodern homes for the most part, but the wilderness around them is complete. The Bethlehem Steel Company 20 miles south of the city mines the ore from El Pao, another iron-rich mountain, and not far away is the El Trueno iron deposit.

The Lost World

The Orinoco, winding sluggishly seaward through swamps and jungles virtually uncharted by man, is the lifeline that links Puerto Ordaz and its germinating industrial complex to the outside world. Ships from Europe and the United States, mostly empty ore-carriers, find their way here, load up, and inch their way back to the markets of commerce. For Venezuela's iron deposits are rich indeed (63 to 65% pure at Cerro Bolivar, for example—highest grade on earth), and her total proved reserves are more than 2 billion metric tons, making Venezuela an assuredly rich nation for the forseeable future.

What Venezuela is now doing at the Orinoco–Caroní junction town of Puerto Ordaz is only the beginning. In money terms, the initial investment alone amounts to $300 million for the steel mill (the second stage of the steel mill will cost an additional $60 million), and $40 million for the power project.

Within a few years, 10 times the present population, more than 100,000 people, will be living in this industrialized area. Thousands of housing units are already under construction. Teams of geophysicists and explorers are fanning out southward into the "Lost World" area. Already they have found iron, gold, diamonds, bauxite, lead, titanium, and nickel. Because the climate of the "Lost World" is temperate, thanks to the rising hills and plateaus that comprise the 14,000-square mile area, it will provide a virgin settlement area for both Venezuelans and immigrants.

Dam and Power Station

The new Macagua dam on the Caroní, south of Puerto Ordaz, will cost $40 million. It will produce 300,000 kw of electrical power through six Francis turbines activating six 50,000-kw generators. Total capacity will not be reached until the early 1960's. By October 1958, however, the first 50,000 kw will be in operation.

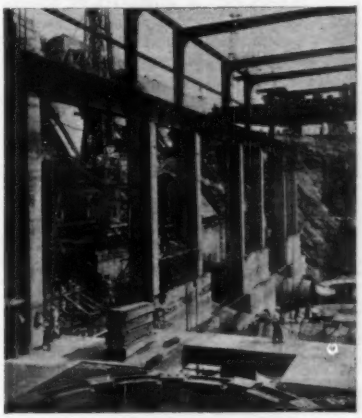
The usual fall of the Caroní's water will be 131.3 feet, but may be as high as 175 feet when the river level recedes—this is largely dependent on the changing levels of the Orinoco itself. When this maximum fall is achieved, each of the dam's generators will have a capacity of 62,000 kw per hour.

Steel Mill

The new steel plant will occupy a tract of 667 acres on the banks of the Orinoco River. Its initial first-stage capacity will be 650,000 tons per year of finished products by 1959. Eventual capacity of 1.2 million tons per year is not expected until late 1960 or 1961. This amount is thought sufficient for Venezuela's own needs at that time.

Housing for Workers and Families

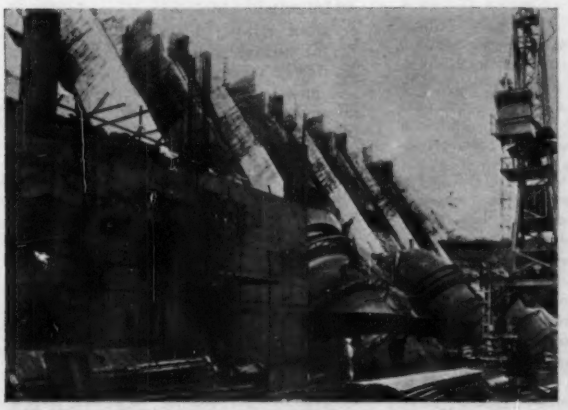
Housing for workers in the first-stage production will be in the neighborhood of



EXPLORATION of "lost world" area has revealed the presence of gold, diamonds, bauxite, nickel, titanium, and lead.

5,000 units for 25,000 inhabitants; second-stage production will require an additional 12,000 units for an estimated 60,000 persons. The new community is planned for completion simultaneously with the first and second stages of steel production. This will involve a total outlay of $1.2 million for housing alone.

This is in addition to more than 10,000 persons now in Puerto Ordaz, concerned primarily with loading the iron ore on ships for export.



MACAGUA DAM Francis turbines, the first of projected six, will be in operation by late 1958, providing the first 50,000 kw of 300,000 kw for the steel mill across the river.

FALLS OF THE CARONI RIVER south of Puerto Ordaz, Venezuela, will produce the 300,000 kw of power to be utilized by steel mill on the opposite shore.

Army Message Printer Device Is First Superspeed Combat Unit

A MESSAGE PRINTER and code puncher was officially unveiled for public demonstration at the Armed Forces Communications and Electronics Association convention at the Sheraton-Park Hotel in Washington, D. C., recently. It is the first in a new family of superspeed combat teletypewriter units.

The new device was developed for the U. S. Army Signal Corps, by Kleinschmidt Laboratories, Inc., a subsidiary of Smith-Corona. It pounds out messages at 750 words a minute—12 times faster than the average typist, 5 times faster than normal conversation, and more than 10 times faster than standard teletypewriter equipment.

Description

The device has no ordinary typing keys. Instead, a whirling wheel rimmed with letters prints the high-speed messages. It spins at 3,750 revolutions a minute—as fast as wheels on a car going 500 miles an hour. At the precise instant the correct letter comes into position, a tiny hammer slaps the paper against the type wheel. Perfection of this technique represents a major breakthrough in the field of mechanical printing.

It types out messages on 7/8-inch paper tape, at the same time punching out coded holes. Tape spews from the printer at 7½ inches per second. These tape messages can be relayed rapidly to other points; or, they could be printed on the spot in page form through the utilization of automatic typewriters.

Communications Speed

As part of a combat communications center, it will be able to rush high-priority messages to widely dispersed mobile command posts. The device is not only five times faster than voice communications, but also it gives a permanent printed record of the message for future reference, as needed.

In the tempo of modern warfare, such speed is essential. Combat units must be widely dispersed to avoid mass destruction, yet closely co-ordinated for united action. Warnings and information on enemy movements must move rapidly and accurately over a broad area. Such new equipment, part of tomorrow's high-speed Army-wide communications system, may save innumerable lives in the event of nuclear combat.

Mobility

The printer can be mounted on a jeep or truck teamed to a mobile forward area communications center. On short notice, the entire center, including the new unit, will be able to pack up, move to a safe location, and go right back into operation almost immediately.

The printer–puncher could also be used to feed battle information into a new mobile combat computer now under development. This electronic "brain" will be able to evaluate tactical information and decide on priority targets faster than any human.

Applications

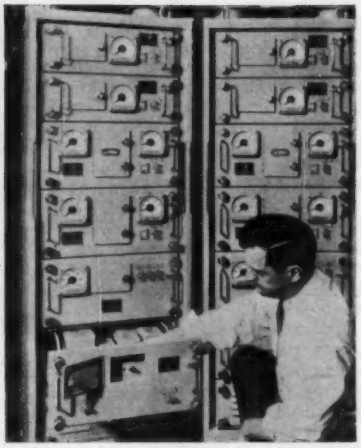
The new printer device is similar to systems used by news services to rush stories to newspapers, radio, and television stations, but it is more than 12 times faster. It could, for instance, receive and print out every word on a full page of a standard-size newspaper in less than 8 minutes.

In future commercial use, the device could speed the transmission of telegrams, stock market quotations, and weather reports. It also has important applications in the field of integrated data processing.

The speed of the tape spewing out of the device is seven inches per second. The Fort Monmouth tests showed this machine to be by far the fastest device of its kind for combat usage.

U. S. Army Photograph

COMBAT TYPER is inspected for message from new superspeed teletypewriter device developed for the U.S. Army Signal Research and Development Laboratory. Mounted on a radio-equipped jeep, the new typer–puncher is tested as part of a unified mobile communications center, of which the radio van in the background is part.



ENGINEER makes adjustment in drawer assembly of nuclear instrumentation system developed by Allen B. Du Mont Laboratories, Inc. Designed to serve as control and safety equipment in either land-based or marine installations, the system will be used to prove out nuclear reactor design of an atomic submarine prototype.

Instrumentation System for Prototype Atomic Submarine

A system of instrumentation for nuclear reactors, designed to serve as control and safety equipment in either land or marine installations, has been developed by Allen B. Du Mont Laboratories, Inc.

Shipped to the Atomic Energy Commission's (AEC) Knolls Atomic Power Laboratory (KAPL) in Schenectady, N. Y., the equipment is to be used in a land-based prototype of a nuclear-powered submarine, a project developed by the General Electric (GE) Company for the AEC.

To be used primarily in proving out the nuclear reactor design in the prototype, the instrumentation will also help establish operational procedures for an atomic submarine. In addition, it will be incorporated in training programs for naval personnel serving aboard such craft.

This nuclear instrumentation system is capable of measuring from one to 10 billion units of neutron flux per second. The rate generally varies between these limits in proportion to the power output of the reactor. Neutron flux is determined by the product of the number of neutrons per cubic centimeter and their average velocity per second.

In operation, the instrumentation system constantly monitors the reactor. It gauges and indicates the density and rate of change of neutron flux of the atomic reactor from "start up" to "full power."

When nuclear activity reaches the upper safety limit, a signal is produced by the instrumentation system which "scrams" the reactor. "Scramming" in atomic jargon refers to an automatic, instantaneous shutdown of a nuclear reactor. Continuous visual indications of nuclear activity are

given by front panel meters and by a remote meter panel.

If neutron flux increases too rapidly, this equipment automatically slows down the nuclear reaction. This limiting action is called "drive down."

Special design of the packaging permits use of the indispensable safety equipment in land-based and surface marine craft, as well as in submarine reactor installations. The complete instrumentation system consists of two cabinets, each measuring 74-inches high by 24-inches deep by 24-inches in width, and weighing approximately 1,000 pounds, plus seven neutron detectors and connecting cables.

Preliminary trials of a prototype of the Du Mont unit were conducted at the Naval Research Laboratory in Washington, D. C.; the Brookhaven National Laboratory, L. I., N. Y.; KAPL; and at Du Mont Laboratories in East Paterson, N.J.

Subjected to rigorous performance checks, tests applied included vibration and high shock, the latter through simulation of conditions experienced in a submarine during a depth charge attack. Operational tests were performed under normal and extreme environmental conditions. These tests covered power supply variations, wide temperature and humidity variations, and subjection of the cabinets to water spray. Operating from a standard 60 cycle a-c source, the nuclear instrumentation system is powerful enough to accept pulses generated by neutron detectors, without preamplification at the detector positions. Simplified, low level circuitry is employed throughout, allowing use of a minimum of vacuum tube components. Duplicate circuitry is also provided throughout for added safety.

The nuclear instrumentation system basically consists of three channels of reactor monitoring equipment. These are a source range channel, intermediate range channel, and a power range channel. All channels are provided in duplicate, again, as an additional safety precaution. Each channel is built into a separate, interchangeable drawer, allowing quick replacement without plant shut down.

Constructed on a fail–safe philosophy of design, the Du Mont system is built so that failures of parts, or parts of assemblies, will cause trip circuits to become or remain de-energized. Failure of any one channel will not affect the operation of any other channel. All channels are provided in duplicate, mechanically and electrically. Test circuits are built into the system to check accuracy of operation.

System Corrects Errors at Electronic Speed without Human Help

DISCOVERY of a method to insure virtually uninterrupted accuracy in electronic data-processing by correcting mistakes "on the fly" at electronic speeds was announced recently by the Datamatic Division, Minneapolis-Honeywell Regulator Co.

The new system, called Orthotronic Control, literally recreates source data by a form of electronic detective work and provides instant data reconstruction of lost or garbled words or figures when discrepancies are automatically spotted at any one of a series of check points throughout the system.

Orthotronic Control was hailed as the most significant breakthrough in the state of the art in the past 10 years by P. B. Wishart, president of the firm. He called it "the final step in electronic data-processing techniques to make the giant 'brains' totally self-disciplined."

"This," he added, "now makes the big systems capable of correcting mistakes with no interruption of work, with no human intervention and with no slackening of the lightning-fast operations."

The word orthotronic derives from the Greek stem-word "ortho" meaning straight. right, true, or correct, and is combined with the end syllables of the familiar word "electronic" to describe aptly the new control.

Production Started

The system has been started in production at Datamatic's two plants near Boston, and will be ready for service with existing and future Datamatic *1000* systems in the second quarter of 1959, the company announced at this presentation.

Up until now, systems for checking and double-checking for transient errors have been developed and used, but previously no method was perfected to make the complex machines self-correcting.

In describing what Orthotronic Control does, and how it works, R. M. Bloch, Datamatic's director of product development, who invented the method, traced the steps of mathematical–electronic formulas which led to its perfection. Ten years ago he developed the processing equipment for automatic checking of digital data, now standard in the industry.

The key development of the new control is that it actually regenerates data a split second before it is processed whenever a mistake shows up. This is accomplished by combining mathematical principles with electronic performance in constantly cross examining each fragment of every letter and figure as it is measured in the dot–dash impulse of speeding electronic tape, he explained. By sensing and correcting errors in the code signals which make up fractions of individual letters and digits, lost, damaged, or garbled words can be literally resurrected and restored to their proper sense and sequence, he added.

Industry Needs Met

Orthotronic Control meets a long-felt need in the industry for replacing the expensive manual correction of error, it was explained, inasmuch as it was impossible for electronic tape operating at speeds of 120,000 decimal digits per second not to be affected occasionally by dust or other

Future Meetings of Other Societies

Illuminating Engineering Society, National Technical Conference, Aug 17-22, Royal York Hotel, Toronto, Ont, Canada.

American Astronautical Society, Annual Western Regional Meeting, Aug 18-19, Dinkelspeil Auditorium, Stanford University, Palo Alto, Calif. M. A. Broner, 3421 Greer Rd, Palo Alto, Calif.

ASME, joint AIChE, Heat Transfer Conference, Aug 18-20, Edgewater Beach Hotel, Chicago, Ill. L. S. Dennegar, ASME, 29 W 39 St, New York 18, N. Y.

The Institute of Radio Engineers

Western Electronic Show and Convention (WESCON), joint WCEMA, Aug 19-22, Pan Pacific Auditorium, Los Angeles, Calif. R. C. Hansen, Hughes Aircraft, Co., Culver City, Calif.

4th National Aeronautical-Communications Symposium, Communications Systems, Oct 20-21, Hotel Utica, Utica, N. Y. (classified symposium, auspices Directorate of Communications, Rome Air Development Center, Oct 22, Griffis Air Force Base, Rome, N. Y. Clearance required) R. C. Benoit, 138 Riverview Pky, Rome, N. Y.

National Council of State Boards of Engineering Examiners, 37th Annual Meeting, Aug 21-23, Hotel Schroeder, Milwaukee, Wis. W. A. Piper, National Council of SBEE, Palmetto State Life Bldg, PO drawer 1404, Columbia, S. C.

ISA, 13th Annual Instrument–Automation Conference & Exhibit, Sept 15-19 (Maintenance Clinic, Sept 14-15), Philadelphia Convention Hall, Philadelphia, Pa. F. J. Tabery, 3443 S Hill St, Los Angeles 7, Calif.

AIME, Rocky Mountain Minerals Conference, Sept 17-19, Newhouse Hotel, Salt Lake City, Utah. H. N. Appleton, AIME, 29 W 39 St, New York 18, N.Y.

AIChE, meeting, Sept 21-24, Hotel Utah, Salt Lake City, Utah. F. J. Van Antwerpen, AIChE, 25 W 45 St, New York 36, N.Y.

SFSA, 56th Fall Meeting, Sept 22-23, The Homestead, Hot Springs, Va. G. K. Dreher, SFSA, 606 Terminal Tower, Cleveland 13, Ohio.

SES, 7th Annual Meeting, Sept 22-24, Benjamin Franklin Hotel, Philadelphia, Pa. F. F. Van Atta, SES, 1916 Race St, Philadelphia 3, Pa.

EIA, Conference on Reliable Electrical Connections, Dec 3-5, Dallas, Texas. Deadline for papers: Aug 15. R. G. Roesch, 1068 S Clinton St, Syracuse 4, N. Y.

Overseas

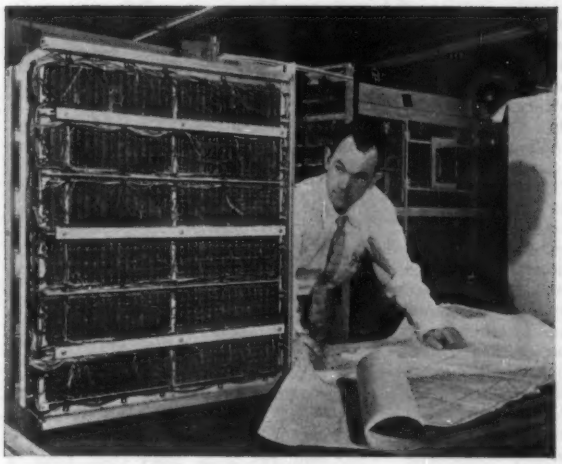
2nd International Conference for Analog Computations, Sept 1-7, Strasbourg, France.

2nd International Conference on Peaceful Uses of Atomic Energy, Sept 1-13, Geneva, Switzerland. U.N.O.

2nd International Congress on Cybernetics, Sept 3-10, Namur, Belgium. Secretariat, International Association for Cybernetics, 13, rue Basse-Marcelle, Namur, Belgium.

ICAS, 1st International Congress of the Aeronautical Sciences, Sept 8-13, Madrid, Spain. Institute of the Aeronautical Sciences, 2 E 64 St, New York 21, N. Y.

Société des Radioélectriciens, International Symposium on Nuclear Electronics, Sept 16-29, UNESCO House, Paris, France. Colloque International "Électronique Nucléaire," 10, ave Pierre-Larousse, Malakoff, Seine, France.



CIRCUITRY CHANGES necessary to add Orthotronic Control to a chassis of the high-speed converter of a Datamatic 1000 is shown being checked by one of the company's highly trained specialists.

adverse influences. All systems today have built-in detection methods by which the machine in effect proofreads its own material and may ring a bell, flash a light, or otherwise say, "I have found an error in the copy." Until now, however, this has then required tedious manual searching of files, or time-consuming reruns of the tape.

Orthotronic Control's nonstop retrieval of data, although requiring no human intervention, will relay to the operator a typed note informing him that a passing mistake has been discovered and fixed.

The development introduces a new technique into the field of electronic data-processing, and is expected to have even wider application in other areas, notably in communications, the company said.

Three-Point Program Includes Missile Research

A 3-point expansion program calling for (1) introduction of new products, (2) creation of departments, and (3) enlargement of existing activities was announced by J. L. Burns, president of the Radio Corporation of America (RCA), New York, N.Y., at the company's 39th annual meeting in May. Describing the program as one positive step toward ending the recession, Mr. Burns said, "We believe that the best way out of a recession is to sell your way out."

Program Detailed. The first of the six new products to be put on the market will be a high-fidelity tape cartridge for home music player—recorders, holding enough tape to provide two hours of regular music or one hour of stereophonic music. One of the most significant departments established is the Astro-Electronic Products Division, set up to develop and produce earth satellites, space vehicles, and their associated electronic equipment. Advances in broadcasting, color television, and automation were pointed out as examples of existing activities which had been expanded under the new program.

National Defense. On the frontier of missile research, activities in research, development, production, and service are being intensified. The company recently signed a 2-year contract with the U.S. Army Signal Corps to exploit a major breakthrough in electronic miniaturization. This breakthrough is attributable to the development of radically new basic components, which are assembled into micromodules employing transistors. Through the use of these micromodules, it is possible to achieve a tenfold reduction in the size and weight of electronic systems for missiles, earth satellites, and field equipment.

To illustrate this reduction, Mr. Burns showed an experimental radio the size of a fountain pen. It is complete with batteries, antenna, and earphone. Its five modules, each about 1/10th of a cubic inch, correspond to the tubes and accompanying circuits of a conventional 5-tube radio receiver. The whole receiver weighs only 2 ounces. The miniaturization achieved in the fountain-pen radio, he said, paves the way for heretofore unrealized developments not only in radio receivers but in nearly every other field of electronics as well.

NSF-Sponsored Institutes for Teachers

The National Science Foundation has announced that proposals will be accepted until September 1 from colleges and universities for the support of 1959-60 Academic-Year Institutes. These Institutes offer full-time study in science and mathematics through programs designed especially to improve the quality of instruction offered by high school science and mathematics teachers. Directions for preparing proposals and forms to be used in making application may be obtained by interested institutions of higher education from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C.

Foundation grants will provide support for 19 Academic-Year Institutes during the 1958-59 school year starting in September. Each Institute will provide instruction for about 50 teachers. Foundation grants enable the sponsoring institutions to offer stipends up to $3,000 plus additional allowance for dependents and travel, and cover tuition and fees, an allowance for books, and operating costs beyond those supported by tuition payments.

Foundation grants extend complete freedom to sponsoring institutions to administer and conduct their respective programs, and teachers seeking training offered by Academic-Year Institutes should apply directly to the sponsoring college or university, not to the Foundation. Although criteria for admission to graduate schools vary among sponsoring institutions, Foundation policy requires that candidates be considered primarily on the basis of professional competence and promise as teachers of science and mathematics. Institutes are designed to provide the type of supplementary subject-matter training needed by the high school teachers whose formal education is represented by a bachelor's degree. Most Institutes will provide for an additional closely allied summer program which may enable many participating teachers to earn graduate degrees.

Coinage Advances in Step with Technology

Coin Thickness Gauged. A unique X-ray gauge is being used by the U. S. Mint at Denver, Colo., in the control of weight of coins. Produced by Industrial Gauges Corporation of West Englewood, N.J., the gauge provides all-electronic control of the thickness of the metal strip from which the coins are formed, so that they do not vary from the extremely close tolerances established for United States coins.

The noncontact gauging system measures and controls the coinage strip on several reduction passes through a finishing mill, by sensing the variation in intensity of X rays beamed through the strip as thickness changes. If the metal begins to deviate from the precise thickness set for each reduction pass, electronic circuits activate the mill controls to correct the error. This electronic circuitry is capable of actuating the mill equipment to control the thickness of the metal to within less than half a ten-thousandth of an inch.

After rolling, coils are slit, blanks are cut from the strip, test weighed, and subsequently annealed, cleaned, upset, and stamped. The number of rejects for over and under weight has been so substantially reduced that the new equipment has increased the Mint's production rate considerably.

Although X-ray gauging equipment has been measuring and automatically controlling the thickness of other types of metal strip for about 10 years, the gauging of coinage strip had never before been attempted by noncontact gauging because of the broad range of thickness (0.038 inch to 0.196 inch) and the wide variety of alloys rolled on a single mill. The alloys in coins range from the heavy alloy of silver, through a nickel base alloy, to a copper alloy for the pennies. To be effective, the control gauge must have precise and unvarying calibration for these alloys and for the wide thickness range.

The alloy and thickness problems were solved with a type of built-in automatic

calibration. When the operator sets control dials for the alloy and thickness (in thousandths), standards within the gauge are checked against gauge indication of strip thickness to assure correctness and uniformity of measurement. These standard thickness values will not vary for the life of the equipment. Studies show that the new automatic controls make 10 times as many major and minor corrections during rolling as the mill operator can. The electronic circuits analyze the changes of thickness, predict the approach of significant change, and actuate the controls to forestall it, thus permitting compensation for deviations before they are apparent to the operator.

Electronic Monetary System. Within 50 to 75 years, more than 200 million Americans may conduct all their financial affairs without the use of cash, coins, or checks, according to industrial design and electronic systems specialists G.M. Hunt and P. E. Lannan of Designers for Industry, Cleveland, Ohio. The only remaining barrier to use of the electronic method seems to be the amount of time necessary to change over our present bulky money-handling system. All typical components of such a system, it is stated, are already understood and can be built with little difficulty.

Under the new monetary system, all bank deposits and withdrawals, all "charge" payments, and all so-called "cash" purchases will be made with the use of individual "electronic pocketbooks," and auxiliary data-processing equipment used by employers, businesses, and banks. Essentially, the system will work in the following manner: the electronic pocketbook will be a laminated metal card, probably plastic coated, about the size of today's driver's license. The card will contain a complex network of printed circuitry. This circuitry will form the basis of an electronic "meter," showing the amount of dollars available to the user. Deposits will send the meter up. Payments will send it down, in gradations as small as 1¢.

Instead of a paycheck, wages will be "posted" on the employee's electronic pocketbook by the employer. This "posting machine" will be wired to a central bank clearing house, which posts a similar withdrawal on the corporate electronic pocketbook. The employee can then use his card to the limit of his deposits in paying bills and making purchases. Each time he makes a purchase or pays a bill, the correct amount will be "withdrawn" from his card at the store where he is doing business. This data will be simultaneously transmitted to the bank clearing house, which electronically deducts the amount from his account.

It is predicted that under this new system checking accounts will be balanced out at electronic speed, check forgeries will be prevented, and embezzling will be practically impossible. Each card will contain, in addition to visible identifications, an invisible electronically coded number which will be assigned to the user. Should the card be lost or stolen, an immediate stop can be placed on all withdrawals against that number, until electronic bank scanners can determine if someone is attempting to use the card wrongfully. Payment of bills by mail will be replaced by telephone payment. Placing the electronic pocketbook in a specially adapted telephone will transmit the code number, plus the amount to be paid, via an individual audio frequency to the proper party. Payments can thus be made simply by dialing the creditor's number.

Pulse Code Modulation in the Telephone Industry

Pulse code modulation is being explored as a possible technique for greatly increasing the information handling capacity of conventional telephone cables. For example, there is a possibility that a single twisted pair may handle 176 telephone conversations simultaneously, or that seven such pairs may handle a complete television signal by utilizing pulse code modulation techniques. A maximum rate of 10 million pulses per second is required on each pair.

In pulse code modulation, continuous or analog information, such as a television signal, is coded into discrete bits of information which may be transmitted over wire or radio links by means of groups of pulses. If six pulses are available in each group, any of 64 different amplitude levels of the analog information may be represented by the presence or absence of pulses in the group.

If the analog information is a monochrome television signal, coding into 64 discrete amplitude levels and then decoding results in very little degradation of the reproduced picture. If each group contains seven pulses, 128 different amplitude levels can be transmitted, and it takes an experienced observer to distinguish between the original television picture and a picture which has gone through the coding and decoding process. Similarly, the quality of voice signals would be maintained during such a coding and decoding process.

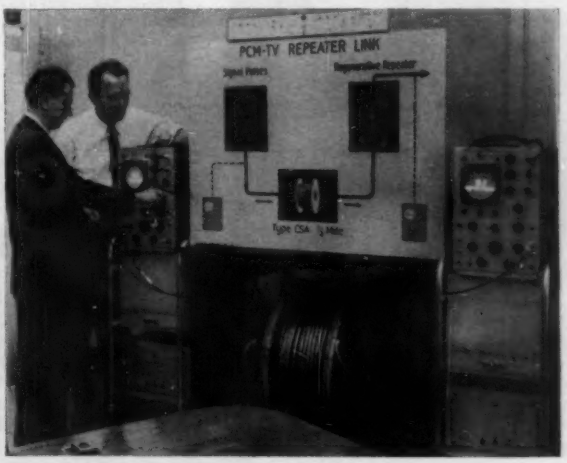
Pulses at the rate of 10 million per second deteriorate very rapidly when transmitted over a twisted pair, making it necessary to regenerate them about every half-mile or so. A transistorized regenerative repeater has been developed which can restore the pulses to their original condition after they have passed through this length of cable. Restoration is complete—there is no degeneration of the pulses and no noise introduced into the signal. Thus, any number of repeaters can be employed and the signal transmitted any distance. This is one of the big advantages of pulse code operation over conventional repeaters.

The regenerative repeater detects the presence or absence of a pulse in the incoming signal. When a pulse is detected, the repeater generates a new pulse, identical to the one originally transmitted. Engineering this repeater is quite a problem, because the transmitted pulses have degenerated after half a mile of transmission to the point where it would be difficult to identify them as pulses in an oscilloscope picture of the signal. One experimental repeater contains only two transistors; if the distance between repeaters is increased to 3,000 feet, as seems desirable, the regeneration can be accomplished in a circuit using three transistors.

The pulses or absence of pulses in each individual code group have a repetition interval of 0.1 microsecond. Each pulse has a duration or width of 50 millimicroseconds and minimum spacing between pulses is also 50 millimicroseconds. Such high-speed pulse operation is possible with tubes, but only recently have transistors been developed capable of operating at these speeds. Better high-speed pulses can now be generated with transistors than with vacuum tubes unless very specialized and expensive tubes are employed.

Each repeater requires around 200 milliwatts of power, and this power can be transmitted on the twisted pair along with the coded signal. Transistorization has made the small power drain and small physical size of the repeaters possible.

Although more research and development is necessary before pulse code modulation comes into widespread use in the telephone industry, enough has already been learned to assure that this valuable technique will become available in the near future for greatly increasing the information-carrying capacity of existing telephone cables.

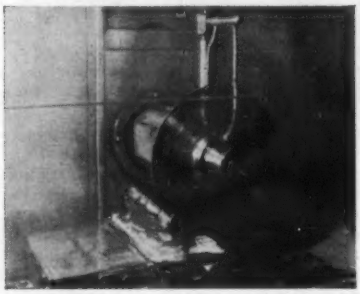


DEMONSTRATING a pulse-code modulator repeater link are R. L. Carbrey *(left)* and A. J. Rack of Bell Telephone Laboratories. Incoming pulses are shown at the left; on the right, the pulses are shown after they have passed through a half-mile of cable and have been amplified by a transistorized regenerative repeater.

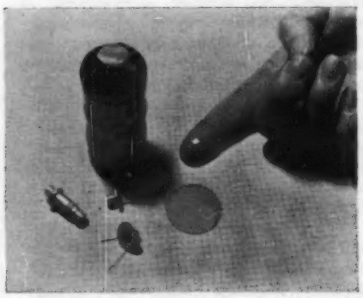
Cutting Silicon Crystal for Rectifier Production

Secrecy surrounding the cutting of silicon crystal for rectifier production was partially removed recently as the Rectifier Division, Audio Devices, Inc., celebrated production of its millionth unit at its Santa Ana, Calif., plant.

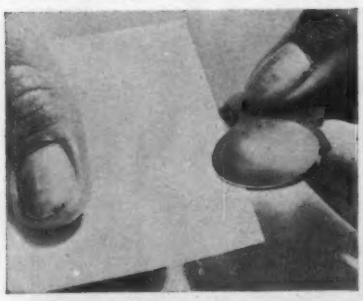
The Division manufactures silicon rectifiers exclusively. Stock items range from 0.750 amperes per 100 volt rectifiers to units rated at 200 amperes per 400 volts. The firm's engineering department is constantly at work designing units for special programs.



SLICING of silicon crystal into wafers at the Rectifier Division of Audio Devices, Inc. In this case a 6-inch, Diatronic diamond cutting wheel is mounted in a micromatic precision wafering machine.



TINY die of silicon crystal is shown on the finger. The disk below the finger is a slice from the crystal which is shown in original form in the upper left. Below the crystal are completed rectifier units.



A CALLING CARD inserted into the saw cut between two silicon slices dramatizes the loss of expensive crystal that occurs during cutting operations. The slices of silicon produced are approximately the same thickness as the card. New thin Diatronic wheels have helped reduce this loss from 65% to 45%.

To the conventional machinist, silicon crystal cutting is a reverse twist—the end product is practically a precision chip, usually 0.10 inch square and 0.013 inch thick. Tolerances are held to 0.001 inch.

Silicon rectifiers became possible when, in 1950, Bell Telephone Laboratories, Inc., developed a method of "growing" monocrystalline silicon. Scientific research contributed to other phases of the manufacturing process, but crystal cutting is essentially the finding of good diamond cutting wheels.

Silicon is in the Group IV elements on the periodic chart, hence, the silicon crystal is tough to cut. So far, diamond cutting wheels have been the only satisfactory solution for slicing and dicing silicon crystal.

In the early days of silicon rectifier production, the only available diamond cutting wheels were either custom made and expensive beyond economic manufacturing cost, or extremely wasteful because of the scratching they caused and the nonprecise thickness of the wheels' cutting edges.

Intrinsic silicon costs $350 a pound and crystal silicon is valued at $5,000 a pound. Conventional diamond wheels cut away over 65% or more of the monocrystal as sawdust. It was natural that silicon unit manufacturers poured hundreds of thousands of dollars into experimenting with cutting methods.

The 14 companies which are today producing the silicon rectifiers used by more than 6,000 electronics manufacturers in the United States, have developed their own individual cutting techniques.

Audio Devices is now using the latest development in diamond wheels called Diatronic. This wheel is available at standard prices in cutting edge widths ranging from 0.006 inch with a tolerance of plus 0.0005 inch, minus 0. With these wheels and using exclusive cutting techniques, the Audio Rectifier Division has cut its sawdust loss to about 45%.

Additionally, the new wheels, which cost from $30 up, cut satisfactorily for 30 days or more. The old wheels lasted from 4 hours to 2 days.

In cutting, the monocrystal is first sawed into "slices" or "disks." These slices are then cemented to a porcelain block and encased in plastic. The slices are then diced.

The dice are then etched to remove saw scratches and dirt. A much higher degree of finish, practically free of scratching, results from use of the new Diatronic wheels.

The next step is to alloy the junction and provide metallic connection to the dice. This is a critical step and the technique for accomplishing it is secret. The final unit is then assembled.

Smaller units are about an inch long. About a pound of these can be connected in series to handle up to 50,000 volts. This compares with the approximately 12 pounds of selenium rectifiers that would otherwise be needed.

Larger silicon rectifiers individually handle 200 amperes per 400 volts. These are used to boost available current for starting airplanes, to raise long distance telephone signals, and to control the polarity of pipelines so that corrosion is minimized.

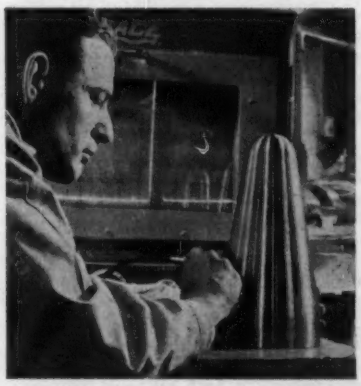
Details Revealed on Nose Cone and Space

Stainless Steel Used. Facts recently released concerning the nose cone of the U. S. Army's Explorer satellite, now circling the earth every 115 minutes, reveal that it is made of stainless steel, type 430. This material was selected because of its high tensile strength and resistance to temperature extremes even when in thin gauges for lightness.

Manufactured by The Lodge & Shipley Co., Cincinnati, Ohio, under contract to the Army Ballistic Missile Agency (ABMC) and the California Institute of Technology Jet Propulsion Laboratory (JPL), the nose cone is 12 inches long and 6 inches wide at its maximum. Thickness of the metal ranges from conical walls of 0.013/0.017 inch to 0.094 inch at the middle of the blunt nose. Its weight before assembly on the instrument package is 13 ounces, which is unusually light for the strength of the shape.

The stainless steel unit not only serves as nose cone for the satellite but is actually the nose cone for the entire Jupiter-C vehicle during initial acceleration in takeoff. The cone is formed by a process, similar to cold-rolling, called the Floturn method, in which the displacement of metal is parallel to the center line of the part being formed.

The Explorer satellite transmits valuable data about its own temperature—a very vital variable because temperature affects the operation of the enclosed instrumentation. Tiny bead-shaped thermistors, whose resistance to electrical impulses changes with changes in temperature, are located in the nose cone. The satellite's environment is also marked by cosmic ray particles and micrometeorites. A low-powered transmitter has broadcast



TECHNICIAN uses Vidigage, a development of Branson Instruments Inc., Stamford, Conn. The ultrasonic resonant gauge is used for final testing of U.S. Army Explorer satellite nose cone's wall thickness. Trace on instrument's cathode-ray tube indicates thickness directly.

micrometeoritic data received from a set of 11 gauges encircling the tubular shell near the tail.

Secrets of the Ionosphere. The area which begins at 50 miles above the earth's surface and extends far into outer space, known as the ionosphere, is being probed by scientists of Space Technology Laboratories, which is a division of The Ramo-Wooldridge Corporation, Los Angeles, Calif., during tests of Atlas intercontinental ballistic missiles launched from Cape Canaveral, Fla.

Dr. D. J. Farmer, head of the Electronic Laboratory's Advanced Research Department experimental research group, said that the company's scientists are seeking to gain data for the Air Force relating to the distribution of free electrons in the ionosphere. The presence of free electrons affects guidance and radio communication, but up to now there has been no precise way of measuring electron density at ionospheric heights. The usual methods of measuring electron density by low frequency waves beamed into the ionosphere and "bounced" back to earth are not accurate enough for missile and space vehicle studies.

Ionospheric investigation is being conducted through use of Doppler radar. Signals emanating from the missile are picked up by ground Doppler radar installations contained in three portable radar trailer units spotted at strategic locations at the testing grounds. By investigating the difference in frequencies recorded by the radar sets, based on knowledge of the missile's speed and altitude, scientists will be able to obtain electron density measurements perhaps 10 times more precise than has been possible heretofore.

Acknowledgment Cards for Amateur Radio Operators

Amateur radio operators, who successfully pick up signals from outer space during calibration of the satellite-Minitrack stations, can now show cards acknowledging their reception.

Before launching of United States satellites, the giant transmitter and antenna of Diana moon radar at the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J., bounce 108-megacycle signals off the moon. This is done so that the far-flung Minitrack station and amateur radio operators can calibrate their receivers for precise tuning to the transmitters aboard the United States satellites.

When amateurs receive the moon-bounced signals, they notify the Laboratory at Forth Monmouth or the American Radio Relay League at West Hartford, Conn. Their help is valuable during the calibration period, and thus the amateurs make a direct contribution to the United States satellite program.

In appreciation of their assistance, the U. S. Army Signal Research and Development Laboratory sends each reporting amateur a customary acknowledgement or "QSL" card—the first ever issued for picking up signals via the moon.

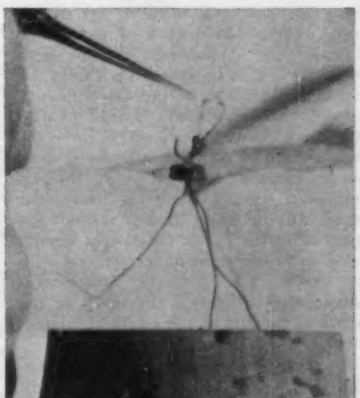
U.S. Army Photograph

MOON CLUB: Amateur radio operators who receive signals bounced off the moon by the U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J., get this acknowledgment card. The space-age method for tuning radios to satellite frequencies is part of the Project Vanguard program. The card was designed by B. H. Christenson, visual information officer of the laboratory, and an amateur radio operator himself.

Field Effect Transistor Amplifier

A transistor amplifier using a semiconductor-electrolyte interface modulated by an electrical field has been developed by J. F. Dewald of Bell Telephone Laboratories. Recent laboratory experiments have demonstrated amplifier operation at 1,000 cps (cycles per second) with gain in excess of 15 db. Initial work on conductivity modulation at a semiconductor-electrolyte interface was carried out at the company's laboratories more than 10 years ago during early studies of transistor action. At that time, minority carrier injection at small area contacts was discovered, leading to the first point contact transistor.

The newly developed transistor amplifier uses a hexagonal rod-like crystal of very pure zinc oxide as the semiconductor, immersed in a highly conducting electrolyte. A platinum electrode placed nearby serves as the grid element. Because zinc oxide is a large-energy-gap semiconductor, it can be operated in a high enrichment condition, with one end of the crystal cathodically biased with respect to the solution, and the other end anodically biased. Somewhere in between is a neutral point which is unbiased, where the energy bands are flat right up to the surface of the crystal. As this neutral point shifts back and forth under the influence of varying biasing grid voltages, the resistance of the crystal changes, passing a current which follows the driving frequency very closely. A fairly extended range of linear response is obtained.



TRANSISTOR AMPLIFIER, using an electrolyte-semiconductor interface, developed at Bell Telephone Laboratories.

In order to make electrical contact to the zinc oxide crystal, the two ends are indium plated first to assure good ohmic contact. They are then copper plated to allow soldering copper wire leads. The platinized platinum grid completes the assembly. After insulating all wires and connections except the grid, the assembly is immersed in the electrolyte (5% sodium tetraborate and boric acid solution), and hermetically sealed in a small glass tube to avoid electrolyte evaporation.

Small size is required to give high-frequency operation. The smallest units constructed so far use crystals about 0.3 mm long, and 0.15 mm in "diameter." It is expected that by going to a flat plate crystal instead of the rod geometry, the present low output power levels could be raised appreciably, without any over-all increase in size, or any change in other operating characteristics.

Developments in Missiles and Helicopters

Sperry Gyroscope Photo

Army Has New "Sergeant." A new solid-propellant ballistic guided missile to succeed the "Corporal" is the U.S. Army's new highly mobile, surface-to-surface ballistic guided missile called the "Sergeant." Officially announced in Chicago, Ill., by the Army, the California Institute of Technology's Jet Propulsion Laboratory, (JPL), Pasadena, Calif., and the Sperry Gyroscope Company, Great Neck, N. Y., it was reported that "the Sergeant missile has the traditional characteristics of its namesake: reliability, versatility, and toughness. For the first time we have a big missile that can be quickly emplaced and fired by a very small crew under all conditions of

weather and terrain. It can deliver a nuclear blow far behind enemy lines and its highly accurate guidance system is invulnerable to any known means of enemy countermeasures."

The over-all length of the Sergeant is approximately 30 feet. It is the latest member of a particular family of Army guided missiles which includes the Private, WAC Corporal, and Corporal, all of which were designed and developed by JPL. Sergeant uses a solid-propellant rocket motor which provides better performance and has greater storage capabilities than those provided by many other weapon systems. It employs improved propellants and materials which incorporate advanced design characteristics that meet the requirements of temperature, shock, and vibration environments to which a missile will be subjected both before and during flight. System elements have been especially designed for portability and mobility and are transportable by standard Army vehicles. The use of solid-propellant and the advanced techniques for guidance have minimized system maintenance requirements and correspondingly simplified ground handling procedures and equipment.

The Army reported that flight tests of the missile made at White Sands Proving Ground, N.M., have actually exceeded expectations for the Sergeant missile system.

One of the Sergeant's predecessors, the last of the WAC Corporal missiles, is leaving JPL, where it was built, and is heading for its final home at the Smithsonian Institute, Washington, D. C. It will become part of the collection of historic American air vehicles there.

The WAC Corporal set its first record in 1945 by climbing to an altitude of 43.5 miles in vertical flight. Later modified as the Bumper WAC, in 1949 it rose more than 250 miles utilizing a German V-2 rocket as the main stage, and represented America's first 2-stage rocket vehicle.

Helicopter Developments. A helicopter flight control system weighing under 40 pounds which holds attitude and heading accuracies within a fraction of a degree has been developed. The unique electronic system was designed by the Sperry Gyroscope Company, Great Neck, N. Y., for use with all types of rotary-wing aircraft. It enlarges the helicopter's role to include the same automatic control capabilities as are provided now for advanced bombers, fighters, and transports and makes possible remote control of helicopter drones from the ground or other aircraft.

HELICOPTER is precisely stabilized in hands-off flight by Sperry Gyroscope Company's automatic flight control system for all types of rotary-wing planes. Equipment provides rotary-wing craft with automatic flight functions and makes possible remote control of pilotless helicopters.

The system operates automatically and continuously to stabilize the aircraft in manual flight and to afford complete "hands off" control when desired. Even in high winds, it maintains accuracies within a fraction of a degree. Complete four-axis control—pitch, roll, heading, and altitude—is provided in the system, which takes its commands directly from the pilot's controls. Automatic features of the system include electronic trimming to compensate for loading changes, automatic turn co-ordination, and push-button controls for precise attitude adjustment.

Insertion of six printed-circuit calibration boards into the basic system "personalizes" it for each type of helicopter. Cost of the calibration boards is a very small fraction of the basic system cost, eliminating the expense of developing new equipment for each type of rotary-wing craft.

A four-way thumb-operated switch on the control stick enables the pilot to select a "reference attitude" to which the helicopter will return automatically if he releases the controls. Minor attitude adjustments are made by "beeping" the four-way switch. A very precise barometric sensor detects altitude deviations and keeps the aircraft at its reference altitude by varying the collective pitch of the rotor.

The system has been designed so that nearly all field maintenance is accomplished by simply plugging in replacement components. Redundancy of circuits in critical components provides further assurance of safety and, in the event of a malfunction, the pilot is able to take corrective action to avert an unwanted maneuver. The system can be installed as a unit, or components controlling individual axes, or combination of axes, may be used separately.

In announcing a development of New York Airways, Inc., R. L. Cummings, Jr., president, stated that the Bendix-Decca Navigator has been installed for operational evaluation in each of New York Airways' five 15-passenger Vertol helicopters delivered in the spring. Under the over-all supervision of the Government's Airways Modernization Board (AMB), New York Airways' helicopters carry the complete system including a pictorial cockpit presentation installed as an integral part of a specially designed instrument panel. The necessary ground stations are operated by the Pacific Division of Bendix Aviation Corporation under contract with the AMB. The Airborne Instruments Laboratories will assist the AMB in the technical conduct of the entire evaluation program.

An electronic device to maintain helicopter engines at constant speeds in flight has been placed in production by the Electronics Department of Hamilton Standard, Broad Brook, Conn., Division of United Aircraft Corporation. Its first installation will be on the Navy *HSS-IN*, a version of the Sikorsky *S-58* which has wide military and civilian use. The unit, developed jointly by the Electronics Department and Sikorsky's Dynamics Section, is a trimming-type control. It electronically senses any fluctuation in rotor speed, amplifies the signal, and relays it within a split second to a servomechanism which changes carburetor manifold pressure so that the previously selected engine speed is maintained. Three panels of transistorized circuits comprise the unit, which is sufficiently rugged to be bolted directly to the airframe without shock mounts.

Conference on Electronic Failure Report

The U. S. Army Signal Equipment Support Agency, Fort Monmouth, N. J., acted as host for the first Electronic Failure Report Conference held recently. Col. A. T. Stanwix-Hay, Commanding Officer of the agency, presented the welcoming address.

The conference, under the chairmanship of V. F. Eyerman, Chief of the Equipment Improvement Branch of the agency, aimed at an exchange of information between the services and industry on the usage, experiences, and problems of using the Electronic Failure Report—a report submitted each time a part is replaced.

The reporting system, similar in the services and in industry, was discussed by each service and representative electronics industries, selected by the Electronic Industries Association and the Aircraft Industries Association.

Chemical Coating To Halt Evaporation

A chemical "blanket" to be used as an inexpensive method of saving water now lost through evaporation has been developed by Columbia University, New York, N. Y., research scientists. Dr. V. K. La Mer, Columbia University professor of chemistry, said that in tests over periods of several months, hexadecanol, or cetyl alcohol, has reduced evaporation by 50 to 65% in reservoirs in the southwestern area of the United States and in Australia.

The harmless chemical applied to the surface spreads out to seal off the water from the air with a layer only one molecule thick—so thin that 1 pound of hexadecanol covers 10 acres as a monolayer. Dr. La Mer said that if savings such as those realized in tests are gained throughout areas such as Texas, in which water is in chronically and sometimes critically short supply, savings could amount to many millions of dollars a year. By contrast, hexadecanol costs about 40¢ a pound and approximately a pound every month per acre of water surface seems sufficient for average conditions.

The researchers have determined that a monolayer successful for practical purposes must be "self-healing," that its effectiveness is drastically reduced by impurities, and that it must coat the surface from bank to bank. So far as they know, the "self-healing" property is possessed only by hexadecanol. By closely approaching

these and other ideal conditions, they have reduced evaporation as much as 10,000 times in the laboratory.

Dr. La Mer stated that widespread use of the evaporation-preventing monolayers now awaits the solution of practical problems such as that of applying and replenishing the chemical to maintain its film against the action of dirt and wind. In one Australian project, experiments in providing a continuous chemical blanket are being made with various sizes of cetyl alcohol pellets held in screens on floats or buoys that are spaced one to the acre.

IRE Plans Summer Seminar

The 19th Annual Summer Seminar of the Emporium Section of The Institute of Radio Engineers will be held on August 21-23 at Emporium, Pa. Publicity Chairman of the Emporium Section D. L. Vergason announced that five technical papers would be presented at the seminar's program. Additional details may be obtained from Mr. Vergason, Sylvania Electric Products Inc., Emporium, Pa.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Illustrations should be submitted in duplicate, one copy and inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Engineer Registration

To the Editor:

At the risk of appearing to be the sort of individual who opposes motherhood and favors sin, I must take sharp issue with many of the arguments advanced in favor of registration of engineers—as typified by the recent article by A. E. Paige ("Your Next Step—Registration," *Electrical Engineering*, June 1958, p. 491).

Those who urge registration say it will bring recognition of engineering as a profession, implying that it does not now enjoy this status. They say that registration will thrust engineers into the same category as doctors and lawyers who must be licensed by the state.

If state registration is an accepted criterion of professional status, then plumbers, barbers, and cab drivers must also be ranked as "professional men," since most states require them to pass a licensing examination. Obviously there is no relationship between state licensing and professional status.

Proponents of registration claim that it will raise the engineer's prestige, and they again cite the licensed doctor and lawyer as proof. (I might again cite the plumber, barber, and cab driver, but there are more powerful answers.)

The doctor and lawyer perform direct, and very personal services, for members of the community at a time when they are faced with serious illness or pressing legal problems. The layman is cured by one, or at the most, several physicians whom he knows by name. The same layman is quite remote from the teams of thousands of engineers who are responsible for producing this nation's aircraft and missiles, or his own automobile.

Another possible reason for the local prestige of doctors and lawyers is the fact that they usually drive bigger cars, live in larger homes, and belong to "better" clubs than the engineer can afford.

Any young man who enters the engineering profession with the primary motivation of "being looked up to" in his community (as Mr. Paige suggests), instead of because he thinks he will enjoy the challenges of engineering, had better switch to medicine or law.

Certainly, the engineer deserves greater public recognition, appreciation, and remuneration for his contributions to society. But will the layman suddenly come to appreciate the engineer the more merely because he has taken and passed a state examination? If anyone seriously believes this, I suggest he walk over to his neighbor tonight, tell him that he has just become a Registered Professional Engineer, and then see if he can detect any perceptible change in his neighbor's attitude in subsequent days. (The average layman probably doesn't even know that doctors and lawyers are licensed.)

The way to raise prestige and professional stature of the engineer in the public's eye is through the efforts of engineers, individually and through their technical societies and companies, to better inform the public and to dramatize the engineer's role in society. For the individual engineer, this includes the use of every opportunity to speak in public to explain the engineer's contribution—but without propagandizing.

Recent events suggest that a few hundred pounds of metal orbiting around the earth have done more to raise the stature of engineering in the public eye than all the registered engineers who have passed state examinations to date.

The original objective, and only real justification for registration of any profession or trade is to provide the means for assuring a minimum standard of competence for the protection of the public. The layman obviously is not in a position to determine in advance whether a doctor or plumber, to whom he must turn for help, has a minimum acceptable standard of competence. State registration provides such assurance, with limitations.

Without periodic re-examination (which few proponents of registration suggest), there is no assurance that the individual has maintained the minimum acceptable level of competence which he once exhibited and proved. This may be acceptable for plumbers and barbers, who are relatively unaffected by technological change. But in many branches of engineering, the supersonic pace of technological advances has outmoded the value of a single examination and life-time registration.

Persons who wish to practice as consulting engineers must obviously become registered engineers, as must those (primarily in the civil engineering field) whose employment requires it.

But the competence of the vast majority of engineers who are employed by corporations can be established more accurately by their supervisors, and associates, than by a state examination which in many instances has undergone little if any revision in the past 20 years, despite the whirlwind pace of technology.

Insofar as the case for registration of newly graduated engineers, the time to erect the hurdles to incompetence is in the engineering college or university—not afterwards. Surely, the faculty is better able to determine the competence of a young engineer on the basis of four years of performance than the state is on the basis of a brief examination.

If there be a case for registration of engineers, beyond its original purpose of protecting the public, let its proponents state it, based on hard cold facts with which engineers are accustomed to dealing—not on by-product advantages which may or may not accrue.

Let us stop crying about lack of professional recognition and admiration and behave like the professional men we are—interested in the challenges and fun of engineering, not in public adulation.

Very truly yours,

P. J. KLASS (AM '47)

(Avionics Editor, *Aviation Week* Magazine, Washington, D. C.)

Britain?

To the Editor:

As a graduate of a British university I was very interested in the recent article "Technical Education in Britain" by D. O. Akhurst. At first I thought the most significant error was in the title, which would have been more correct as "Technical Education in England," even though as a Scot who has paid British Income Tax I was somewhat galled by reference to the *English* Treasury. The confused use of the word "English" instead of "British" is something to which we non-English Britons are becoming used, and we are inclined now to let such misnomers ride

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rather than be thought quibbling. But we do not think this subject trivial.

However, in the article, Glasgow (Scotland—postal area North Britain) is mentioned which suggests that the reference to Britain in the title was intentional. In that case, the four Scottish Universities—Aberdeen, Edinburgh, Glasgow, and St. Andrews—and the University of Wales with its several Colleges should be added to the list of 15 degree-granting Universities. To the list of Colleges of Advanced Technology, the Royal College of Science and Technology at least should be added.

The above assumes that "Britain" is to be taken in its strictest sense and does not include Northern Ireland, which has its own seats of learning.

Yours truly,

A. S. DENHOLM

(National Research Council, Canada, Electrical Engineering Section.)

To the Editor:

It is generally recognized that short review articles such as "Technical Education in Britain" cannot offer the reader complete coverage of the subject and for this reason references were included for further reading, for example, in the case of Scotland. Further, it is well recognized that Scotland has been in the forefront of progressive education for over 400 years; indeed the Scottish Education Act to make primary education compulsory was passed as long ago as 1496.

It is also recognized that care must be taken when studying British statistics and for exactly this reason all the statistics presented have been correctly associated with those areas of Britain to which they refer. The term "English Government" was used in a general sense with no intention of offending the Scots.

Yours sincerely,

D. O. AKHURST

(Massachusetts Institute of Technology, Assistant Professor of Electrical Engineering)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

A FURTHER HANDBOOK OF INDUSTRIAL RADIOLOGY. By members of The Non-Destructive Testing Group of the Institute of Physics. Edward Arnold, Ltd., London, England; distributed in the United States by St. Martin's Press, 103 Park Ave., New York, 17, N.Y., 1957. 334 pages, 5¾ by 8¾ inches, bound. $12.50. Intended to supplement the "Handbook of Industrial Radiology" issued in 1949. New material is included which incorporates such advances as the production of radiation of high energy and great intensity, the advent of a supply of radioisotopes, and electronic progress which makes possible automatic inspection. Some subjects not previously covered in the handbook, such as fluoroscopy and stereoscopy, have now been included.

A HISTORY OF MAGIC AND EXPERIMENTAL SCIENCE. Volumes VII and VIII: The 17th Century. By Lynn Thorndike. Columbia University Press, 2960 Broadway, New York 27, N.Y., 1958, 695 and 808 pages, 5¾ by 8¾ inches, bound. $10 per volume. These two concluding volumes discuss the development of experimental science during the 17th Century and its liberation from superstitious conceptions. Among the myriad aspects and names touched upon, detailed consideration is given to Francis Bacon, Descartes, Huygens, and Boyle, as well as to Harvey's theory concerning the circulation of the blood, the publication of the "Principia" by Newton, and the astronomical studies of Galileo.

ASTM STANDARDS ON ELECTRON-TUBE MATERIALS. Published by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1957. 242 pages, 6 by 9 inches, paper. $3.50. This is the first collection of standards devoted to electron-tube materials to be issued by the ASTM. The standards included relate to cathode materials, insulators, strip materials, wire, metallic and nonmetallic seals, and miscellaneous materials.

APPLIED STATISTICS FOR ENGINEERS. By William Volk. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 354 pages, 6¼ by 9¼ inches, bound. $9.50. Concerned with the treatment of engineering data for correlation, precision, and analysis of experimental factors, it emphasizes engineering applications rather than theory and provides a number of illustrative examples. A review of probability theory and frequency distribution is included as are detailed discussions of curvilinear correlation, the analysis of variance, and the interpretation of the analysis of variance.

THE EFFECTS OF RADIATION ON MATERIALS. Edited by J. J. Harwood and others. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y., 1958, 355 pages, 6¼ by 9¼ inches, bound. $10.50. Theories and concepts of radiation effects, radiation sources, and measurements of radiation are presented, as are the known effects of radiation on the physical, metallurgical, mechanical, corrosion, and electrical properties of materials. Among the materials dealt with are metals, alloys, inorganic dielectrics, semiconductors, organic and polymeric materials, and materials for nuclear reactor components. Comprises papers delivered at the Colloqium on the Effects of Radiation on Materials at Johns Hopkins University in 1957.

ELEKTRONIK FREIER RAUMLADUNGEN. By Franz Ollendorff. Springer-Verlag, Vienna, Austria, 1957. 620 pages, 6¾ by 9¾ inches, bound. $23.35. A systematic treatment of the electronics of free space charges, particularly those whose life is strictly determined. The separate chapters deal with fundamental phenomena, free space charge fields, single and multigird fields, space charge oscillation, and magnetically controlled fields. An extensive bibliography is provided, including many English language references. This volume is part two of the second volume of the author's Technische Eletrodynamik.

ERGEBNISSE DER HOCHVAKUUMTECHNIK UND DER PHYSIK DÜNNER SCHICHTEN. Edited by M. Auwärter. Wissenschaftliche Verlagsgesellschaft, Stuttgart, West Germany, 1957. 282 pages, 6½ by 9½ inches, bound. 52 DM. A group of papers dealing with high-vacuum technology and with the physics of thin layers, subjects of interest to engineers in many fields. Sample topics are the following: technical problems in vacuum production for mercury rectifiers, changes in material properties of thin layers during the evaporation process, measurement of the thickness of a layer with the aid of an optical interference filter, and structure and growth of thin vapor-deposited fluoride layers.

FERN- UND SUMMENFERNZÄHLUNG. By Franz Kuhn. Verlag G. Braun, Karlsruhe, West Germany, 1957. 216 pages, 6 by 8½ inches, bound. 32 DM. Telemetering and remote summation metering. Following an introductory outline of the principles and methods of remote metering, sources of current, and impulse repeating, the book surveys the design and operation of demand meters as well as remote meters. It covers indicating, printing, and perforating devices, and discusses applications. The influence of impulse storing is also discussed and examples of the calculations for summation and differential metering are given.

THE FUNDAMENTAL CONSTANTS OF PHYSICS. By E. R. Cohen and others. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., 1957. 287 pages, 6¼ by 9¼ inches, bound. $7.50. A survey of the present state of our knowledge of the fundamental constants and conversion factors of the physical sciences and of the modern precision measurements from which that knowledge is drawn. Topics included are: arbitrarily defined physical units and standards, classical measured constants and units, masses of atoms and mesons, postwar high-precision measurements, the method of least squares, and least squares adjustment of the atomic constants.

GMELINS HANDBUCH DER ANORGANISCHEM CHEMIE. Eighth edition. Verlag Chemie, Weinheim/Bergstrasse, West Germany. System No. 28: Calcium, Part B, Lieferung 2, 1957, 656 pages, 7 by 10 inches, paper. 219 DM ($52.56); System No. 60: Kupfer, Part B, Lieferung 1, 1958, 624 pages, 7 by 10 inches, paper. 349 DM ($83.76). This exhaustive review of the chemical and metallurgical literature provides a compilation of technical data on the respective elements and their compounds, as well as references to the sources from which the information came. Of the current issues, the Calcium Volume covers Ca compounds with H, O, N, F, Cl, Br, I, and S. The Copper Volume covers Cu compounds with the same eight elements, and with Se and Te as well. For each compound data are given for structure, chemical and physical properties, thermodynamic characteristics, and other pertinent information, graphs and tables being utilized where a series of figures is available. The literature reference is cited immediately after each item of the included data.

A GROWTH SURVEY OF THE ATOMIC INDUSTRY, 1958–1968. By F. H. Warren and others. Atomic Industrial Forum, Inc., 3 E. 54th St., New York 22, N.Y. 1958. 84 pages, 9 by 11½ inches, spiral binding. $25. Examines the business potentials of the nuclear industry based on the experience of large commercial power plants. The programs for nuclear development in Europe are also considered in relation to the effect that these programs would have on the nuclear industry in the United States. In addition, such aspects as fuel and fuel processing requirements, reactor components, and military programs are investigated.

A HANDBOOK OF LATTICE SPACINGS AND STRUCTURES OF METALS AND ALLOYS. By W. B. Pearson. Pergamon Press, 122 E. 58th St., New York 22, N.Y., 1958. 1,044 pages, 6¼ by 10 inches, bound. $38. A reference work on the structures and lattice spacings of binary and ternary alloys. Part 1 is a general introduction to the X-ray investigation of metals and alloys with emphasis on the use of structure determination and lattice spacing measurements to provide information on the physical state of metals and alloys, particularly equilibrium diagram determination. Part 2 is a compilation and assessment of published X-ray work on metals and alloys in equilibrium with alloy systems listed in alphabetical order.

HIGH-SPEED DATA PROCESSING. By C. C. Gotlieb and J. N. P. Hume. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 338 pages, 6¼ by 9¼ inches, bound. $9.50. Covers high-speed data processors of all types and all manufacturers. There is a detailed study of coding and programming with special emphasis on the value of flow charts in the analysis of problems. A variety of examples and illustrations are given for typical applications in the major fields. Recent aspects, such as over-all reliability and checking of results, use of large random-access stores, and form of files, are discussed.

INTEGRAL EQUATIONS AND THEIR APPLICATIONS TO CERTAIN PROBLEMS IN MECHANICS, MATHEMATICAL PHYSICS, AND TECHNOLOGY. By S. G. Mikhlin. Pergamon Press, 122 E. 55th St., New York 22, N.Y., 1957. 338 pages, 5¾ by 8½ inches, bound. $12.50. An advanced text divided into two parts, the first dealing with the fundamentals of integral equations. The second and largest part is given over to practical applications involving one-dimensional and two-dimensional problems such as the statical theory of elasticity, immersed bodies in hydrodynamics, and the theory of oscillations.

INTERNATIONAL CONFERENCE ON SPECTROSCOPY, PROCEEDINGS. Proceedings of the 6th Conference, May 1956. Published as a supplement to Spectrochimica Acta, 1957; available separately from Pergamon Press, 122 E. 55th St., New York 22, N.Y. 663 pages, 7½ by 10 inches, bound. $25. A considerable number of papers are included which deal with such aspects of spectroscopy as flame spectroscopy, emission spectrometry, arc emission, spark emission, instrumentation in relation to emission, instrumentation of absorption methods, ultraviolet absorptiometry, and infrared spectroscopy.

MAINTAINABILITY OF ELECTRONIC EQUIPMENT, PROCEEDINGS OF THE EIA CONFERENCE, 1957. Sponsored by the Engineering Department, Electronic Industries Association, and published by Engineering Publishers, GPO Box 1151, New York 1, N.Y., 1958. 104 pages, 8½ by 11 iches, paper. $5. Papers on the requirements for maintainability and the practical means by which acceptable maintainability levels can be designed into various types of electronic equipment. Ground and airborne applications are discussed as are missile applications. Case histories are given for the Nike-Ajax and the Falcon missile systems.

NOTES ON ANALOG-DIGITAL CONVERSION TECHNIQUES. Edited by A. K. Susskind. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. Various pagings, 6 by 9¼ inches, bound. $10. Presents the subject matter in three parts: the first discusses systems aspects of digital information processing that influence the specifications for analog-to-digital and digital-to-analog conversion devices; the second part presents a detailed engineering analysis and evaluation of a variety of conversion devices; and the third is devoted to a case study based on development work done at the Servomechanisms Laboratory of the Massachusetts Institute of Technology. The book has been reprinted with corrections from the edition published by the Technology Press of MIT in 1957.

NUCLEAR REACTOR EXPERIMENTS. By the staff of Argonne National Laboratory. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1958. 480 pages, 6¼ by 9¼ inches, bound. $6.75. Problems relating to the design, construction, and operation of nuclear reactors are outlined with details of equipment and experiments. Areas included are nuclear radiation detection, moderator and subcritical assemblies, cross sections, operating reactors and their characteristics, heat removal from a reactor, corrosion and radiation effects, fuel preparation, and separation processes.

ORDINARY DIFFERENCE-DIFFERENTIAL EQUATIONS. By Edmund Pinney. University of California Press, Berkeley 4, Calif., 1958. 262 pages, 6¼ by 9½ inches, bound. $5. Provides practical techniques for dealing with difference-differential equations where provision is made for a time lag between past and present action. An introductory section indicates the nature and use of various methods of solution, followed by a detailed discussion of the infinite series solution as well as methods of finding the roots of the characteristic equation. The book also deals with first and second order mixed difference-differential equations. Techniques are applicable to design of guidance systems, prediction of business trends, and numerous engineering problems.

PETROLEUM REFINERY ENGINEERING. By W. L. Nelson. Fourth edition. McGraw-Hill Book Co., Inc., 330 W. 42nd St., N.Y. 36, N.Y., 1958. 960 pages, 6½ by 9½ inches, bound. $15. Useful both as a text and as a handbook, it includes methods of processing petroleum, the design of refinery equipment, the evaluation of crude petroleum for the yield of products, the practical usefulness of petroleum products, and the cost of refinery equipment and its operation. Physical and thermal properties have now been revised to include jet fuels and rocket fuels. A new appendix analyzes over 70 foreign crude oils as well as about 90 representative United States oils for comparison.

PHYSICS OF NUCLEAR FISSION. Translated from the Russian by J. E. S. Bradley. Pergamon Press, 122 E. 55th St., New York 22, N.Y., 1958. 182 pages, 5½ by 8½ inches, bound. $9. Originally published as a supplement to the Soviet journal "Atomnaya Energiya," this is a collection of papers revealing the status of Soviet research in nuclear fission as of 1956. Topics discussed include: fast neutron fission cross-sections, charge and mass distribution of fission products, anistropy in fission processes, fission neutrons, some features of nuclear fission at high and low excitation energies, spontaneous fission of heavy nuclei, and photo fission.

PLANT ENGINEERING PRACTICE. By the editors of Plant Engineering. F. W. Dodge Corporation, 19 W. 40th St., New York 18, N.Y., 1958. 694 pages, 9 by 12 inches, bound. $18.50. A collection of articles offering solutions to problems encountered in daily practice by plant engineers. They are arranged according to the following major aspects: sites and layout, construction, safety, materials handling, maintenance, paints and protective coatings, mechanical power and piping systems, electric power, lighting, heating, ventilating and air conditioning, instrumentation and quality control, and shopwork.

PROGRAMMING FOR AN AUTOMATIC DIGITAL CALCULATOR. By K. H. V. Booth. Academic Press, Inc., 111 Fifth Ave., New York 3, N.Y., 1958. 238 pages, 5¾ by 8¾ inches, bound. $7.50. Illustrates the processes of programming by reference to automatic digital computers now in use. Aspects dealt with include input and output, division and square root, nonarithmetic programmes, matrix operations, simultaneous linear equations, mechanical translation, an interpretive programme for decimal tapes, interpretive routines and pseudocodes, fault finding, and automatic programming.

STRAIN GAUGE TECHNIQUES. Lectures and laboratory exercises by W. M. Murray and P. K. Stein, presented at Massachusetts Institute of Technology, July 1957. Distributed by The Society for Experimental Stress Analysis, P.O. Box 168, Central Square Station, Cambridge 39, Mass. 2 volumes, 8½ by 11 inches, paper. $15. A thorough review of strain gauge techniques which covers such aspects as mechanical and electrical aspects of the gauge system, the potentiometer circuit, the Wheatstone Bridge, design of highsensitivity circuits using galvanometers, common zero balancing, multiple gauge bridge circuits, determination of amplifier characteristics, amplitude modulation, calibration of a strain-indicating system, dynamic strain measurement, and Rosette analysis. Detailed laboratory experiments are also explained.

SYMMETRISCHE KOMPONENTEN IN DREHSTROMSYSTEMEN. By August Hochrainer. Springer-Verlag, Berlin, West Germany, 1957. 364 pages, 6½ by 9½ inches, bound. 45 DM. Starting with the vector diagram for sinusoidal vibrating quantities and the simple laws for currents and voltages in electric networks, the author develops the fundamentals of the method of symmetrical components for the calculation of 3-phase systems. Particular attention is paid to the effect of the relation of various impedances, including the symmetrical impedances of transformers, electrical machines, and overhead lines.

SYMPOSIUM ON RADIOISOTOPES. Published as Special Technical Publication No. 215 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1958. 94 pages, 6¼ by 9¼ inches, bound. $2.75. Papers dealing with testing techniques utilizing radioisotope tracing. The wide range of possibilities is illustrated by case histories involving electroplating, the evaluation of rubber deterioration, the mechanism of detergency, and the achievement of process control by means of tracers during refinery operation.

TELEVISION IN SCIENCE AND INDUSTRY. By V. K. Zworykin and others. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 300 pages, 6 by 9¼ inches, bound. $10. Following an introductory section on the application of television to industry, medicine, and other purposes, the equipment that has been developed is described in detail. Camera design and circuitry of conventional equipment are discussed along with color and stereo-television apparatus, the electron microscope, and new developments in miniaturization made possible by the introduction of the half-inch vidicon and the transistor.

THEORY OF DIELECTRICS. By H. Fröhlich. Second edition. Oxford University Press, 114 Fifth Ave., New York 11, N.Y., 1958. 192 pages, 5½ by 8¾ inches, bound. $4.80. The properties of dielectric materials are systematically studied to provide a background for the physicist, chemist, and electrical engineer. The author discusses the macroscopic theory, static dielectric constant, dynamic properties, and applications. This edition contains additional material on the theory of the static dielectric constant.

TRANSIENTS IN ELECTRICAL CIRCUITS. By G. V. Lago and D. L. Waidelich. The Ronald Press Company, 15 E. 26th St., New York 10, N.Y., 1958. $7.50. Following introductory chapters on the classical method of solving ordinary linear differential equations by using electrical circuits as examples, the Laplace transform method of solving integro-differential equations is presented. A number of applications are discussed including steady-state response to nonsinusoidal wave shapes and the extension of circuit theory methods to mechanical and electromechanical systems. The concluding chapters deal with Fourier series, integrals, and transforms in the solution of various circuit problems.

TRANSISTOR TECHNOLOGY, Volume I. By members of the technical staff of Bell Telephone Laboratories. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1958. 661 pages, 6¼ by 9¼ inches, bound. $7.50. An extensive study dealing with the theory and fabrication of germanium transistors. This volume, which is the first of a series, presents the basic framework, and covers the technology of germanium materials, preparations of single crystals, principles of device fabrication, principles of transistor performance characterization, and transistor reliability. The presentation follows approximately the chronology of the development of knowledge concerning the subject. An appendix gives definitions and letter symbols relating to semiconductors.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to: R. H. Phelps, Director, Engineering Societies Library, 20 W 39 St., New York 18, N. Y.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

CYBERNETICA. Published by the International Association for Cybernetics (IAC), this new quarterly review contains scientific articles on subjects relating to the various areas of cybernetics. Each issue includes an average of four articles and, whenever there is

sufficient material, a special feature called "Recent Publications" is included. One page is devoted to news of the activities of the International Association for Cybernetics. The first issue, published in May 1958, contained articles by G. R. Boulanger, president of the IAC, and by Norbert Wiener, professor of mathematics at the Massachusetts Institute of Technology, among others. Members of the IAC may subscribe to the quarterly for 150 Belgian francs per year; nonmembers, 300 Belgian francs per year. Information concerning subscription payment, further details of the quarterly, and membership in IAC may be obtained by writing Association International de Cybernetique, Secretariat, 13 Rue Basse-Marcelle, Namur, Belgium. Also available from IAC is a volume containing the texts of the lectures given at the two International Meetings for Information on the Economic and Social Implications of Automation, December 1957.

IMPEDANCE MATCHING. Volume 23 of the John F. Rider Electronics Technology Series, edited by Alexander Schure, deals with the problems of impedance matching at audio, radio, and higher frequencies. It treats all kinds of devices used as the generator and a wide variety of equipment used as the load in electrical and electronic circuitry. The theory underlying problems of impedance matching as well as the solutions are explained. Numerical examples illustrate the application of appropriate equations. The book contains 128 pages and is heavily illustrated. It may be ordered, at $2.90, from John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y.

KUNSTSTOFFE. English translations of outstanding papers and articles from foreign countries in the field of plastics science and engineering have been made available by the publishers of *Kunststoffe*, a leading European plastics technical journal published in West Germany. The usual German edition of *Kunststoffe* has been enlarged, as of the July 1958 issue, by the addition of a supplement, "German Plastics Digest," which contains condensed English language translations of the most important articles appearing in the journal every month. Subscriptions for the expanded magazine are $32 annually, and should be sent to Carl Hanser, Zeitschriftenverlag GMBH, Munich 27, West Germany.

1954-1955 BIBLIOGRAPHIC SURVEY OF CORROSION. Publication No. 58-1 of the National Association of Corrosion Engineers (NACE) was compiled by A. I. Humphrey. Containing a selection of 4,287 abstracts of articles on corrosion and corrosion prevention published in 1954-1955, this volume also includes a number of abstracts published from 1945 to 1953 which were not available for use in earlier bibliographies. Material was selected from abstracts compiled by 23 agencies covering literature internationally. Abstracts are arranged topically in eight main groups: general, testing, characteristic corrosion phenomena, corrosive environments, preventive measures, materials of construction, equipment, and industries. Each main group is subdivided and topical cross-references are appended. An author index is included. An appendix has been included to aid the user in locating and obtaining copies of unfamiliar foreign or domestic journals. The bibliography may be ordered from NACE, 1061 M & M Bldg., Houston 2, Texas. Price: nonmembers NACE, $20; members NACE, $15.

ASTM STANDARDS. Availability was announced of two compilations of American Society for Testing Materials electrical–electronic standards. "Metallic Electrical Conductors B-1" contains 55 standards of which 3 are completely new and 13 are revised or have had their status recently changed. It supersedes the December 1955 edition. Among the materials covered are copper, copper alloys, copper-covered steel, aluminum, and galvanized steel and iron. The 334-page volume is priced at $3.75. "Electron Tube Materials," compilation of Standards F-1, contains 41 standards relating to cathode materials, insulators, strip materials, wire, metallic and nonmetallic seals, and miscellaneous materials. It is available at $3.50. Both books may be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

OTS REPORTS. A proposal for reducing midair collisions of aircraft through use of communication and computer techniques has been advanced by the U. S. Navy, and is described in two technical reports released through the Office of Technical Services (OTS), U. S. Department of Commerce. The authors, P. J. LaRochelle and R. E. Brescia of the Naval Research Laboratory (NRL), state that the most reliable method for significantly decreasing air collisions is a co-operative-data collision-avoidance system in which the velocity components, available in each cockpit, are communicated as they are needed. Ruling out such proposals as self-contained data-gathering techniques as inadequate in supplying information for quick decision-making and escape maneuvering, they maintain that present traffic control systems cannot meet the demands of speed and density requirements of modern aircraft. Development of a reliable operational navigation system and adequate ground-to-air control appears many years away, according to LaRochelle and Brescia. Their interim solution involves a combination of communication and computer techniques which would accept data from aircraft instruments, interrogate similar installations in other aircraft, and give control commands to insure safe clearance of airplanes in the same general airspace. Instrumentation for the system would include a radar to measure relative position, an interrogator–transponder to allow private communication, and computer elements to solve equations. The 45-page preliminary report of the system is contained in *PB 131589* Aircraft Collision - Avoidance System Requirements, April 1958, price $1.25. The 7-page supporting article appears in the March 1958 issue of the monthly *PB 131681* Report of NRL Progress. The single issue of this series (which sells at a subscription rate of $10 a year) costs $1.25. Both publications may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C.

23RD SEMI-ANNUAL ELECTRIC POWER SURVEY, April, 1958. This report presents the results of the 23rd Semi-Annual Electric Power Survey conducted as of April 1, 1958, by the Electric Power Survey Committee of the Edison Electric Institute (EEI) in co-operation with representatives of the electric power systems, or power areas, throughout the United States, and the nation's principal manufacturers of heavy electric power equipment. The survey covers approximately 98% of the capability and 99% of the energy output of the electric power systems of the country, including both investor-owned systems and those of governmental agencies—Federal and non-Federal. Throughout this report all data relating to power system capabilities, loads, gross margins, and energy outputs are based on the specific coverage of the survey, no attempt being made to adjust them for 100% coverage. Data for past years in this report, therefore, may differ slightly from other published statistics representing complete coverage of the industry. Definitions of the terms used, together with information concerning methods of summarizing the data, are given in an appendix. The report, EEI Publication No. 58-7, may be ordered from Edison Electric Institute, 750 Third Ave., New York 17, N. Y., at $1.

RECOMMENDATIONS FOR MAGNETIC TAPE RECORDING AND REPRODUCING SYSTEMS: DIMENSIONS AND CHARACTERISTICS. The purpose of this international standards recommendation of the International Electrotechnical Commission (IEC) is interchangeability of magnetic tape recordings throughout the world. The recommended standard, IEC Publication 94, applies to nonperforated magnetic tape and equipment used for sound recordings and sound reproduction in both professional and domestic applications. Among the specifications established are the mechanical and electrical requirements of recordings and sound reproducing equipment, nominal tape speed and tolerance, position of the active surface of the tape, position and dimension of the magnetic sound track, and spools. Provisions are also made for standard adapters that permit European machine fittings to receive American spool hubs, and vice versa. Furthermore, the dimensions, minimum tensile strength, flammability, and identification of tape sides of magnetic tape are specified, as well as tape leaders, program identification, start of programs, and identification by the leader and label on recorded tape. Copies of IEC Publication 94, at $2.40 each, are available in the United States from the American Standards Association, 70 E. 45 St., New York 17, N. Y.

MAGNETIC RECORDING TECHNIQUES. By W. E. Stewart, chief engineer, The Standard Register Company, this is a guide to the technology of magnetic recording devices and techniques, written for engineers and technicians in the various fields utilizing magnetic recording. Principles of the recording and reproducing processes, recording materials, the theory of ferromagnetism, recording mechanisms, and established standards are covered, and design techniques for the various elements of magnetic recording systems and ways to obtain better performance in many new fields of application are shown. Included are definitions, tables, derivations of key formulas, and practical test circuits. Recording and reproducing functions are discussed separately to help analyze the effect that each has on the recording media and on the over-all performance. The 268-page handbook, containing 150 illustrations, is available at $8.50 from McGraw-Hill Book Company, Inc., 327 W. 41st St., New York 36, N. Y.

DIRECTORY TO NUCLEAR DATA TABULATIONS. By R. C. Gibbs and Katherine Way, of the National Academy of Sciences–National Research Council, this directory contains descriptions of 295 tables useful in basic nuclear science, grouped into 34 subject sections. Among the topics covered are: abundances, Coulomb functions, cross sections, fission, masses and mass differences, mesons and hyperons, nuclear properties, radiochemistry, and X rays. In addition to the usual bibliographical information, each entry includes authors' institutions, price (other than for journals), and details on availability and ordering procedures. A topical index and an author index have been included. The paperbound directory is available at 70¢ from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Payment should be by check, money order, or document coupons, and must accompany order. Remittances from foreign countries should be made by international money order, or draft on an American bank, payable to the Superintendent of Documents, or by UNESCO book coupons. (Add 25% to total cost of order for postage to foreign countries, including Argentina, Brazil, British, Dutch, and French Guiana, and British Honduras.)

SPECIAL LIBRARIES ASSOCIATION TRANSLATION CENTER (SLA). Located at the John Crerar Library in Chicago, Ill., the SLA has announced that it can now furnish, on a subscription basis, printed catalog cards for current scientific and technical material which has been translated into English from all languages, including Russian. This effort of the Center to facilitate the exchange and growth of scientific knowledge in the Western world will make available in card form the thousands of citations given in the Center's bibliographical journal, *Translation Monthly*. Four types of subscriptions to translation catalog cards are available: (1) full coverage of *Translation Monthly* (approximately 12,000 titles yearly); (2) coverage of all translations currently received by the Center (approximately 6,750 titles yearly); (3) coverage of all Russian translations received by the Center (approximately 3,100 titles yearly); and (4) coverage of all titles in specific subject fields. The SLA Translation Center is a depository for unpublished scientific material which has been translated into English. It collects translations from Government agencies, industry, technical societies, and educational institutions, making copies of these translations available to other research groups and individuals. Users may borrow paper copies of desired translations or may purchase microfilms or photoprints of translations. To keep libraries and information centers informed of new translations, the Center publishes *Translation Monthly*, a listing of translations recently received by the Center as well as translations available from commercial agencies. Further information about the SLA Translation Center and its services may be obtained from The SLA Translation Center, The John Crerar Library, 86 E. Randolph St., Chicago 1, Ill.

Venus, in blue light. 200-inch Palomar telescope.

SPACE FLIGHT and NUCLEAR PROPULSION

A drastic reduction in vehicle mass ratios... substantially increased specific impulse values... a capability for achieving very high speeds... these are some of the significant advantages that will come from the application of nuclear energy to space flight.

A number of different propulsion systems have been proposed to utilize nuclear reactions. The simplest system consists of a fission reactor through which the propellant is passed, heated, and then expanded through a rocket nozzle. Fission reactors can also be employed as a source of energy to generate electric power, which in turn can be used to accelerate ions or charged particles, or to create and accelerate a plasma. And fusion reactors, when developed, can be used to generate electric power for the same purposes. In addition, in the case of the fusion reactor, there is the attractive possibility that the reaction energy can be used directly without conversion to electric power.

The fission-powered thermal propulsion system will probably constitute one of the next major advances in space technology. As an example of the gain which can be achieved, consider a vehicle with a payload weight of about 25 tons for a manned flight to one of the nearer planets, landing, and returning. Powered by chemical rocket engines, the takeoff weight for such a vehicle would be 50,000 tons. But powered by a fission-thermal propulsion system, weight at launch would not exceed 500 tons... a 100-fold reduction in the mass ratio. Considerably greater gains are predicted for the more advanced systems.

Systems studies and advanced research in the application of nuclear energy to the requirements of space flight are in progress at Space Technology Laboratories. This work illustrates the emphasis at STL on the exploration and development of new concepts and techniques in ballistic missile and space technology.

Both in support of its over-all systems engineering responsibility for the Air Force Ballistic Missile Program, and in anticipation of future system requirements, STL is engaged in a wide variety of analytical and experimental research. Projects are in progress in electronics, aerodynamics, hypersonics, propulsion and structures.

The scope of activity at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding professional opportunities on the STL Technical Staff are invited.

SPACE TECHNOLOGY LABORATORIES

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MIL-T-27A POWER AND FILAMENT TRANSFORMERS AND HERMETICALLY SEALED FILTER REACTORS

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POWER TRANSFORMERS-STANDARD
All primaries 105/115/125 v., 60 c.p.s.

Cat. No.	Hi Volt Sec.	ct	DC Volts	DC Amps	Filament #1 Volt	Filament #1 Amp.	Filament #2 Volt	Filament #2 Amp.	MIL Case Size
MGP1	400/200	√	185	.070	6.3/5	2	6.3	3	HA
MGP2	650	√	260	.070	6.3/5	2	6.3	4	JB
MGP3	650	√	245	.150	6.3	5	5.0	3	KB
MGP4	800	√	318	.175	5.0	3	6.3	8	LB
MGP5	900	√	345	.250	5.0	3	6.3	8	MB
MGP6	700	√	255	.250					KB
MGP7	1100	√	419	.250					LB
MGP8	1600	√	640	.250					NB

FILAMENT TRANSFORMERS-STANDARD
All primaries 105/115/125 v., 60 c.p.s.

Cat. No.	Secondary Volt	Secondary Amp	Test VRMS	MIL Case
MGF1	2.5	3.0	2,500	EB
MGF2	2.5	10.0	2,500	GB
MGF3	5.0	3.0	2,500	FB
MGF4	5.0	10.0	2,500	HB
MGF5	6.3	2.0	2,500	FB
MGF6	6.3	5.0	2,500	GB
MGF7	6.3	10.0	2,500	JB
MGF8	6.3	20.0	2,500	KB
MGF9	2.5	10.0	10,000	JB
MGF10	5.0	10.0	10,000	KB

HERMETICALLY SEALED FILTER REACTORS
Meet MIL-T-27A Specifications

Catalog No.	Inductance Henry	Rat. Current DC Ma.	DC Res. Ohms	Test Volt Kilovolts	Case No.
MGC 1	100	10	3,500	1.	AJ
MGC 2	4	50	230	1.	AJ
MGC 3	10	50	325	1.	EB
MGC 4	20	50	475	1.5	FA
MGC 5	30	50	650	1.5	FA
MGC 6	3	75	175	1.	AJ
MGC 7	6	75	235	1.5	EB
MGC 8	12	75	265	1.5	FA
MGC 9	3.5	100	145	1.	EB
MGC 10	8	100	180	1.5	FA
MGC 11	12	100	190	2.	GA
MGC 12	2	150	92	1.5	EB
MGC 13	4	150	115	1.5	FA
MGC 14	8	150	125	2.	GA
MGC 15	11	150	120	2.5	JB
MGC 16	2.5	200	70	1.5	FA
MGC 17	4	200	80	2.	GA
MGC 18	7	200	135	2.	HB
MGC 19	10	200	125	2.5	JA
MGC 20	2.5	300	50	2.	GA
MGC 21*	4	300	62	2.5	HB
MGC 22	6	300	85	2.5	JB
MGC 23*	8	300	65	2.5	KB
MGC 24	10	300	100	2.5	LA
MGC 25*	2	400	37	2.5	HB
MGC 26	6	400	60	2.5	KB
MGC 27*	2	500	35	2.5	JA
MGC 28	4	500	45	2.5	KB
MGC 29*	7	500	50	2.5	MB
MGC 30*	2	700	20	2.5	LB
MGC 31*	1.75	1,000	12.5	2.5	MB

*Not stocked, available on short delivery.

Send for NEW 48 page transformer catalog. Also ask for complete laboratory test instrument catalog.

FREED TRANSFORMER CO., INC.
1700 Weirfield St., Brooklyn (Ridgewood) 27, N.Y.

Circle 13 on the card.

NEW PRODUCTS

Network Protector Kit. A 3-phase network protector kit for field testing any network protector on the system up through 480 volts at 50 to 60 cycles is now available. The device is arranged so that an over-all operation test can be made of the protector, followed by individual checks of various parts. For further information, write Westinghouse Electric Corporation, P.O. Box 2099, Pittsburgh 30, Pa. *Circle 201 on the card.*

Radioactive-Gas Survey Meter. Intended primarily as a tritium detector, the Levinthal Model *N85SM* radioactive-gas survey meter is useful for detecting leaks in systems containing other radioactive gases as well. Basically, it is composed of an ionization chamber through which air is continuously drawn by means of a blower operated by a selfcontained storage battery. Ion current in the chamber is indicated on a meter relay which can be adjusted by the operator to actuate an internal alarm buzzer at any predetermined level. For further information: Levinthal Electronic Products, Inc., Nuclear Division, Stanford Industrial Park, Palo Alto, Calif. *Circle 202 on the card.*

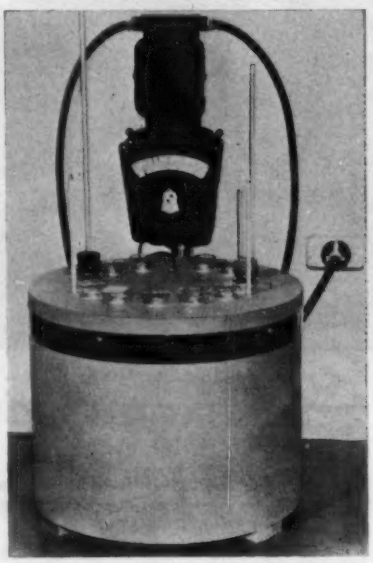
Model 6 Juno. This instrument is a portable, battery-operated survey meter which measures the intensity of, and distinguishes between alpha, beta, and gamma radiation. It is used to protect personnel from the danger of overexposure to radiation from radioactive materials or X rays. The Model *6* is a new version of the Juno available in 2 models: *SRJ-6* (standard range): 50, 500, and 5,000 milliroentgens per hour full-scale; and *HRJ-6* (high range): 250, 2,500, and 25,000 full-scale. Both models meet AEC specifications. For complete details, write for Bulletin No. *159*. Address inquiries to Technical Associates, 140 W. Providencia Ave., Burbank, Calif. *Circle 203 on the card.*

Recording Annunciator. Pinpointing trouble and providing information for quick analysis of equipment failures is the dual service of the recording annunciator recently developed by Panalarm Division of Panellit, Inc., 7401 N. Hamlin, Skokie, Ill. The unit was designed and produced specifically to provide a compact, permanent record of the off-normal and return-to-normal operations of power substation equipment. It also has wide application in other fields where an accurate record of equipment operations is desirable. *Circle 204 on the card.*

Volume Units Meters. Occupying at least 15% less panel space than comparable units, volume unit meters that meet American Standard C16.5–1954 are now being offered by Assembly Products, Inc., Chesterland, Ohio. These meters are being supplied in the model *561* housing that exposes only the indicating area. The remaining 30% of the meter is mounted behind the panel. *Circle 205 on the card.*

Snap-In Junction Terminal Bushing. The snap-in Heyco junction terminal bushing is a miniature nylon receptacle offering to industry a new quick-connect means for access through housings without pig-tail wire leads or screw terminals, for modernization of component installation and removal, for control component snap-in, for rapid motor hookup, output change, or reverse rotation, for multiple electronic circuit changes, and for hundreds of applications in the electrical, electronic, and design modernization fields. More information or answers may be obtained from Heyman Manufacturing Company, Kenilworth, N. J. *Circle 206 on the card.*

Laboratory Aging Block. The Comet Model *600* aging block is a new precision testing device for determining the aging characteristics of natural rubber, synthetic



and light polymers, silicones, plastics, and similar materials under closely controlled temperatures ranging from 100 to 600 F. Equipped with 13 individual test tube compartments, the Comet completely eliminates errors caused by migration and contamination of materials. Manufactured by Product Packaging Engineering, Culver City, Calif. Information may be obtained from C. P. Hall Company, 1340 E. 6th St., Los Angeles, Calif., or 414 S. Broadway, Akron, Ohio. *Circle 207 on the card.*

Centering Microscope. Manufactured by the F. T. Griswold Manufacturing Co., this microscope enables machinists to locate tool spindles precisely over the work. Centering the work accurately to within 0.0005 inch before making a cut, the centering microscope eliminates false starts from imperfect jigging. Complete information is available from the manufacturer, F. T. Griswold Manufacturing Co., 315 W. Lancaster Ave., Wayne, Pa. *Circle 208 on the card.*

(Continued on page 32A)

Announcing

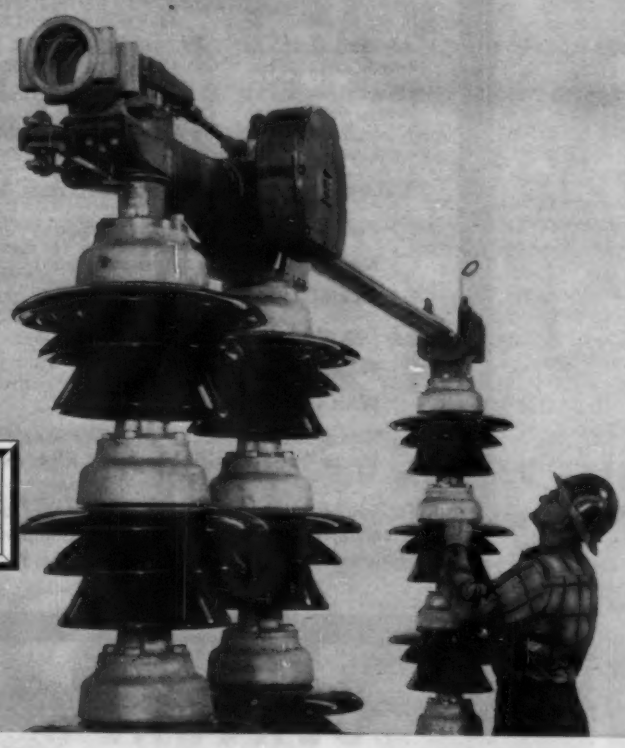
The HM50 SWITCH

A modern high voltage disconnect . . . from 69 HKV to 230 KV

Here is the answer for the system engineer who wants a switch designed to meet the severe demands of modern high voltage systems . . . requirements that can no longer be met by beefing up old designs.

The HM50 is completely new. We believe it marks a definite advance beyond the switchgear presently offered. The utmost capacity of its contact system is not yet known—it continued to function efficiently at the extreme output of the testing facility—over 120,000 amperes.

Some of the major features of the HM50 are: a completely controllable rotating blade; multiple finger contacts and a triple locking system that insures protection during short circuits. It is easy to operate, maintenance free and able to stand the degree of momentary surge possible with today's interlocking systems.



If you have not yet seen a full description of the HM50 . . . Write us for Bulletin 334.

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Representatives in principal cities

For more information circle 14 on reader service card.

Now! A bigger choice of G-E high current silicon rectifiers

MORE THAN 290 TYPES LET YOU MATCH RECTIFIER TO JOB MORE ACCURATELY AT LESS COST

Start With These Basic Units

	Type 4JA60 series	Type 4JA62 series
Maximum Allowable Transient Peak Inverse Voltage (5 millisec. max. duration)	100 to 500 (increments of 50 v)	100 to 500 (increments of 50 v)
Maximum Peak Inverse Voltage	50 to 400 (increments of 50 v)	50 to 400 (increments of 50 v)
Operating Junction Temp.	200°C	150°C
Max. Ave. Forward Current Per Cell		
Stud temp.		
@ 80°C		64 amps
@ 110°C	92	41 amps
@ 130°C	76	24 amps
@ 180°C	29	
Max. Allowable 1-Cycle Surge Current	900	900 amps
Typical Forward Voltage Drop		
@ 70 amps	1.0	1.0 volts

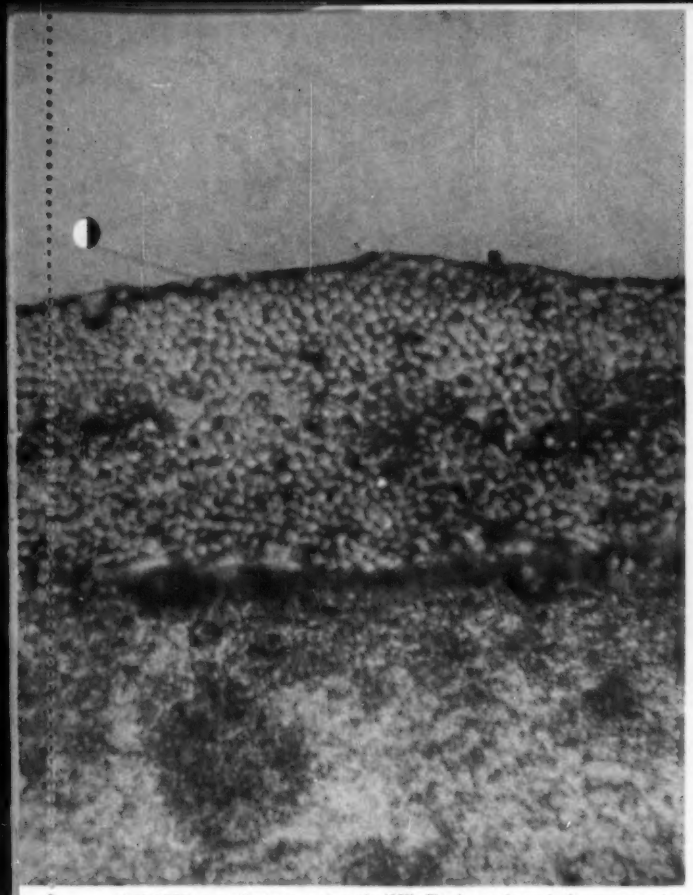
Then Pick the Variations You Need

- ☐ **Positive polarity (stud is cathode)**
- ☐ **Negative polarity (stud is anode)**
- ☐ **Flexible braided lead**
- ☐ **Top stud**
- ☐ **Without fin**
- ☐ **With unmounted single fin**
- ☐ **Hundreds of stacked combinations for almost every circuit requirement. Up to 12 fins with inputs as high as 840 volts.**

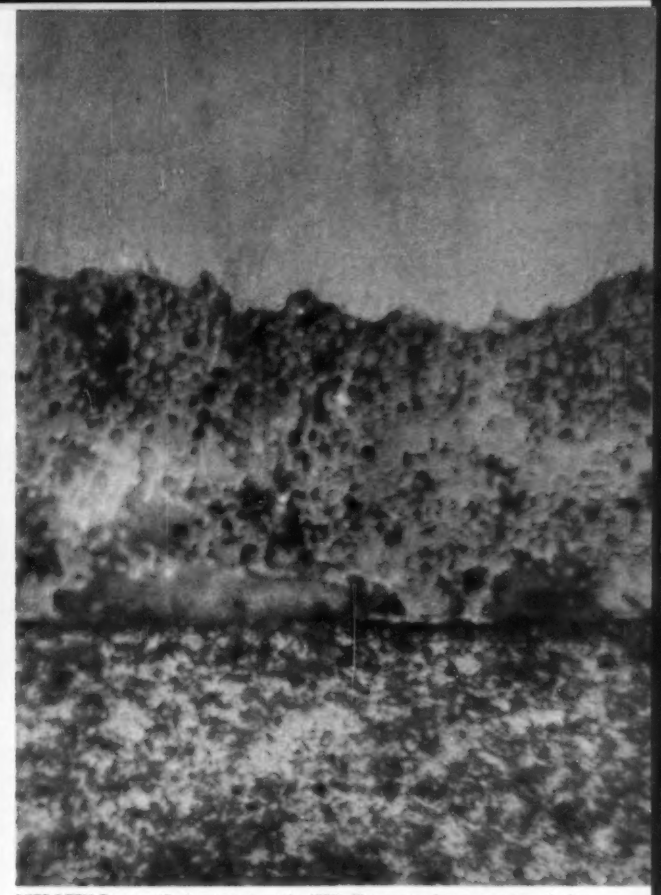
For complete application and performance data call your G-E Semiconductor Representative, or write General Electric Company, Semiconductor Products Department, Section S1888, Electronics Park, Syracuse, New York.

GENERAL ELECTRIC

For more information circle 15 on reader service card.



VITROTEX, magnified approximately 400X. The lower layer is the copper wire; the upper layer, the glass insulation. The glass fiber-ends appear as small circles in the photograph. The sections between fibers are occupied by bonding varnish. Notice the fibers are close together, well distributed.



VITROTEX-D, magnified approximately 400X. The upper layer consists of glass fibers in fused Dacron®. Notice the even distribution which provides uniform insulation value—no large "islands" where fibers are missing.

®Reg. U. S. Pat. Off., Dupont

Let these Anaconda photomicrographs help you select high-temperature Magnet Wire with glass-type insulation

These two longitudinal sections of Anaconda magnet wires have been blown up 400 times—to show you the difference between Anaconda Vitrotex and Vitrotex-D (both 130°C—AIEE Class B).

Maximum high-temperature protection in glass-type insulation depends on the proportion of the glass fibers present. Maximum resistance to winding damage, however, can call for reducing the number of glass fibers and adding a "damage reducing" agent such as Dacron.

This is essentially the difference between Vitrotex and Vitrotex-D. Anaconda provides both—in complete size ranges, in rounds, squares and rectangulars. You, the designer, must weigh the need for insulation and heat-resistance against those properties which affect windability.

Vitrotex, as the left-hand photograph shows, consists of all glass fibers—therefore, where winding damage is controllable, Vitrotex offers you greater insulation value.

Sometimes, however, the risk of winding damage cannot be avoided. For these situations, Anaconda offers Vitrotex-D. The Dacron acts as a bonding agent—holds the fibers in place and protects them during winding.

The pictures above show more than the difference in glass-fiber content. They show how Anaconda engineering and manufacturing care provide uniform fiber distribution in both types . . . how each has been designed to do a different job—and do it well!

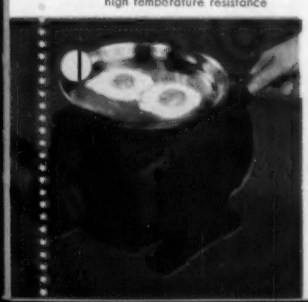
Ask the Man from Anaconda for additional details on (1) Vitrotex, (2) Vitrotex-D, (3) Silotex† (180°C—AIEE Class H) and (4) Silotex-D†. See "Anaconda" in your phone book, in most principal cities, or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

†Reg. U. S. Pat. Off.

SEE THE MAN FROM **ANACONDA®** FOR **MAGNET WIRE**

For more details on the characteristics of Vitrotex and Vitrotex-D, please turn the page—

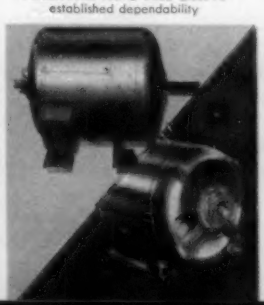
ANATHERM 155°C (AIEE Class H) high temperature resistance



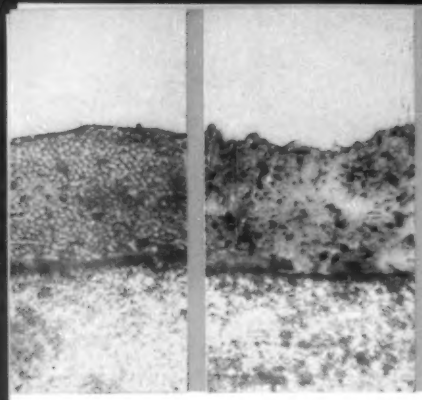
NYFORM 105°C (AIEE Class A) superior windability

PLAIN ENAMEL 105°C (AIEE Class A) low-cost enameled magnet wire

FORMVAR 105°C (AIEE Class A) established dependability



ANALAC 105°C (AIEE Class A) solderable magnet wire



MAGNET WIRE DATA SHEET

from

Anaconda Wire & Cable Co.

IMPORTANT FACTS FOR YOUR WORK...

...about Anaconda Vitrotex 130°C (AIEE Class B) Magnet Wire

HIGH TEMPERATURE OVERLOAD PROTECTION. Even under severe overload conditions, Vitrotex provides protection. This exceptional high-temperature resistance is Vitrotex's outstanding advantage—and can be put to use even in totally enclosed applications.

REDUCTION IN FRAME SIZE. Because of the higher temperature stability, excellent space factor (compared with cotton), and the high heat conductivity of the glass fibers, Vitrotex-wound motors and generators can be produced in smaller frame sizes for equal rating or with increased ratings in comparable size frames.

TECHNICAL PROPERTIES

MECHANICAL PROPERTIES. Vitrotex has the necessary abrasion-resistance for most winding applications. It is suitable wherever controllable winding is possible. Vitrotex possesses remarkable space factor, especially when considering its ability to withstand high operating temperatures. Single Vitrotex has a space factor better than single cotton of equal gage. Double Vitrotex has a space factor better than double cotton of equal gage. Vitrotex has good "mesh" factor—windings expand no more than other insulations so that special precautions are unnecessary in design of windings.

ELECTRICAL PROPERTIES. Vitrotex is offered as a 130°C (AIEE Class B) magnet wire. Its high-grade organic bonding varnish plus the glass, give Vitrotex high electrical qualities. Vitrotex will retain sufficiently high dielectric strength to operate satisfactorily at temperatures above the destruction point of organic fiber insulation. At high relative humidity, Vitrotex retains its dielectric strength to a marked degree.

CHEMICAL PROPERTIES. Vitrotex is compatible with most Class B bonding varnishes and materials. Windings with Vitrotex can be baked after impregnation at temperatures that would destroy ordinary insulations. Windings can be impregnated with commercial varnishes or other compounds by standard methods. While the glass fibers themselves will not absorb liquids or compounds, the interspaces of the insulation will take up and retain the impregnant. Allows great latitude in design.

THERMAL PROPERTIES. Vitrotex is a 130°C (AIEE Class B) magnet wire by definition. However, the precise temperature at which Vitrotex wire can be operated will depend on the design of the apparatus. For example, Vitrotex is excellent for use in dry-type transformers under Group 2 NEMA classification for operation at 150°C hottest spot. Under severe overload conditions where all bond and varnish are destroyed, the inorganic glass remains to protect against shorting.

...about Anaconda Vitrotex-D 130°C (AIEE Class B) Magnet Wire

WINDABILITY. Vitrotex-D is a high-temperature AIEE Class B magnet wire with special abrasion-resistance properties. Where a controllable winding operation is not possible (making the use of all glass insulation impractical), Vitrotex-D is recommended.

PRECAUTION: Dacron is a polyester. Therefore the use of this wire is limited to ventilated equipment.

TEAR OUT FOR YOUR FILE

TECHNICAL PROPERTIES

MECHANICAL PROPERTIES. Vitrotex-D exhibits superior abrasion-resistance. It is ideally suited to those situations where a high-temperature Class B magnet wire is needed, but where the winding operations from the standpoint of abrasion, small bending radii or forming stresses are too severe to permit the use of all glass insulated wire. Use of Vitrotex-D on rectangulars results in thinner insulation and thus improves space factor.

ELECTRICAL PROPERTIES. As in the case of Vitrotex, Vitrotex-D is offered as a 130°C (AIEE Class B) magnet wire. The same high-grade, organic bonding varnish is used in Vitrotex-D as in Vitrotex—giving this wire similar high electrical properties.

CHEMICAL PROPERTIES. The chemical properties of Vitrotex-D are similar to those of Vitrotex except, since Dacron is a polyester, care should be taken in the selection of the proper varnish.

THERMAL PROPERTIES. Vitrotex-D shows the same general thermal properties as Vitrotex—with excellent aging and heat-resistance. Since less glass is present in the covering, less protection is provided under severe overload conditions.

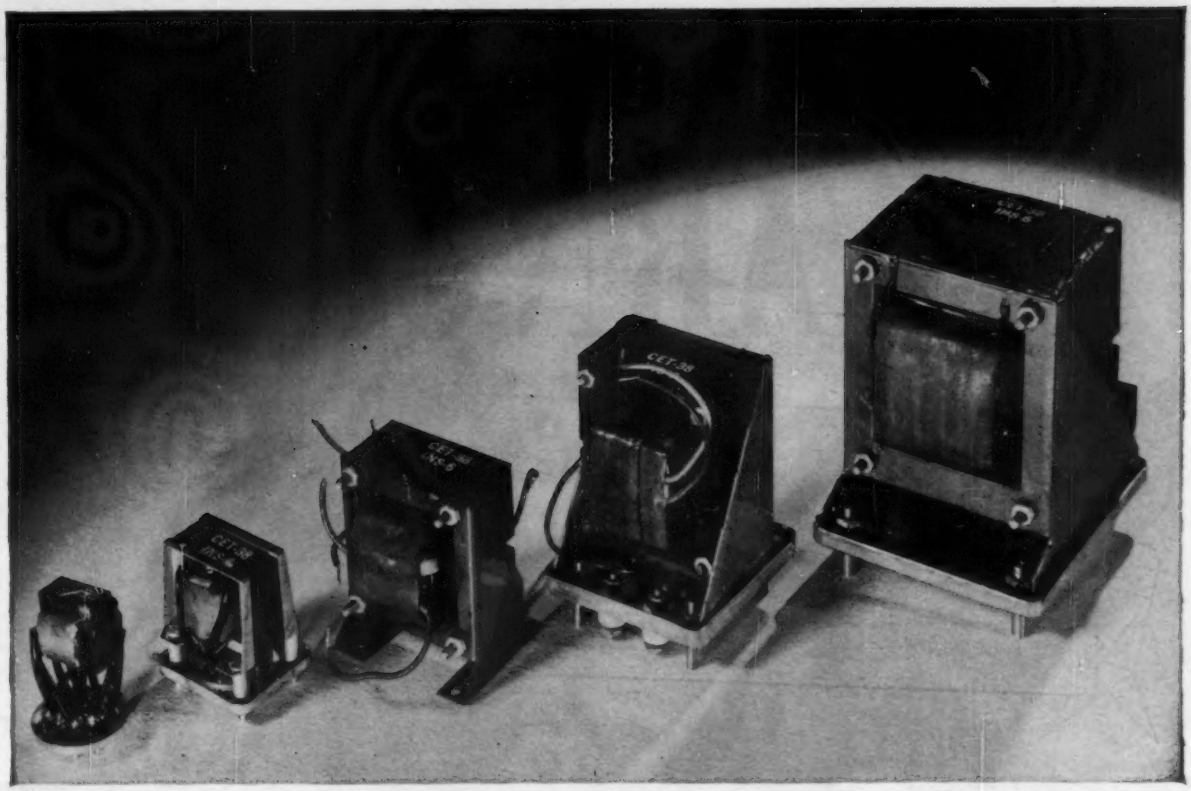
SEE THE MAN FROM

ANACONDA®

FOR

MAGNET WIRE

Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.



A Transformer becomes a precision device with Allegheny Magnetic Materials in the core

Write for your Copy

"TRANSFORMER LAMINATIONS"

84 pages of valuable technical data on standard and custom-made laminations from all grades of Allegheny Ludlum magnetic core materials. Prepared from carefully checked and certified laboratory and service tests —includes standard dimensions, specifications, weights, etc. Sent free on request . . . ask for your copy.

ADDRESS DEPT. EL-8

★ **ALLEGHENY SILICON STEEL**

★ **ALLEGHENY 4750**

★ **ALLEGHENY MUMETAL**

The operation of a transformer is no better than the magnetic core around which it is built. With Allegheny magnetic materials in the core, you get the *best*—uniformly and consistently.

Sure there are reasons why! For one thing, there's the long experience of a pioneer in development and quality control of electrical alloys. But most important, the A-L line offers complete coverage of any requirement you may have, any service specification. It includes all grades of silicon steel sheets or coil strip, as well as Allegheny Silectron (grain-oriented silicon steel), and a wide selection of special high-permeability alloys such as Allegheny 4750, Mumetal, etc.

In addition, our service on magnetic materials includes complete lamination fabrication and heat treatment facilities. What's more, this extensive experience in our own lamination stamping department is a bonus value for all users of A-L electrical sheets or strip. ● Let us supply *your* needs. ***Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.***

STEELMAKERS to the Electrical Industry

Allegheny Ludlum

WAD 9333

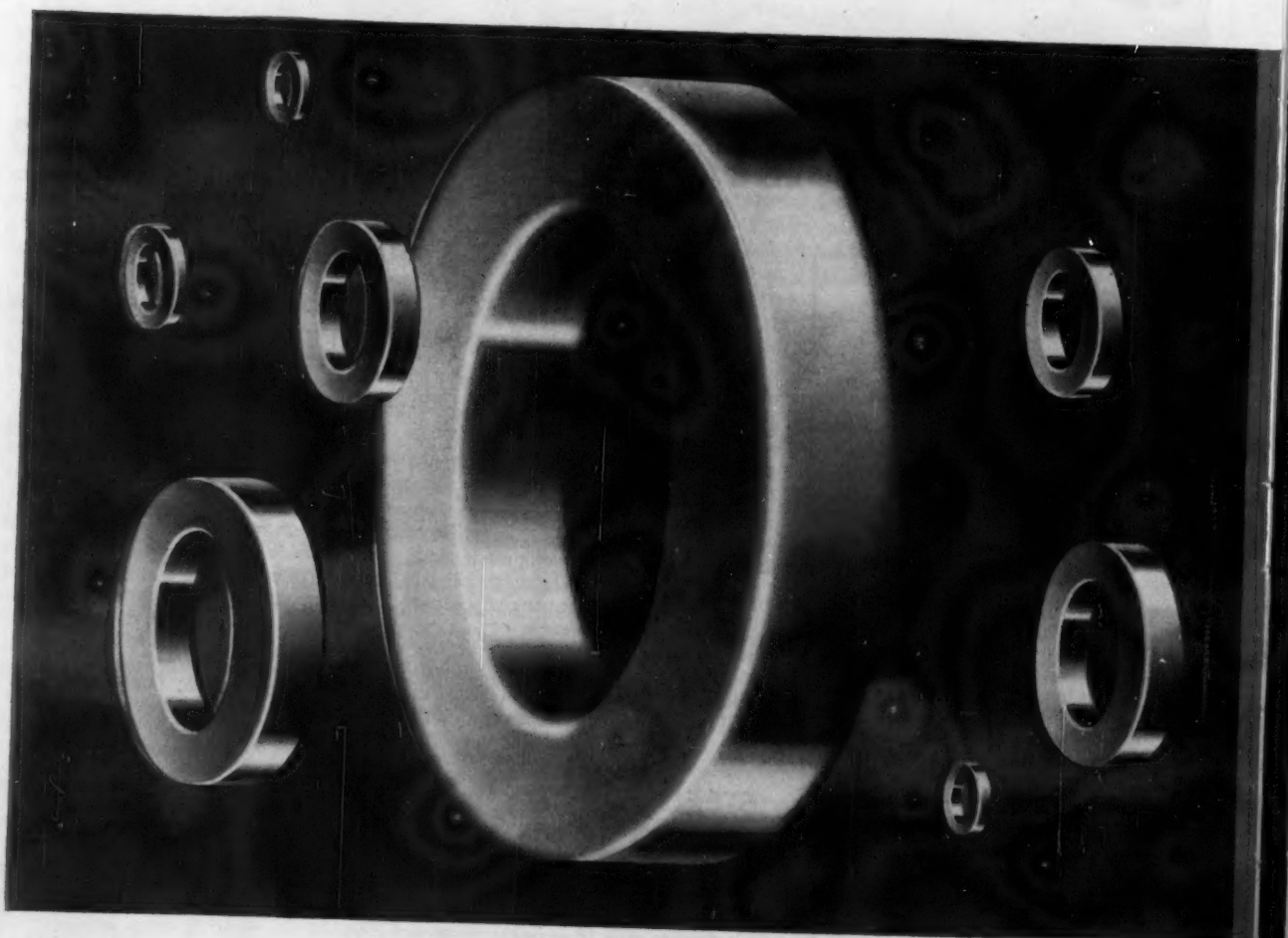
AL
STEELS FOR THE ELECTRONIC AGE

For more information circle 17 on reader service card.

IT'S NEW AND NEWS from ARNOLD

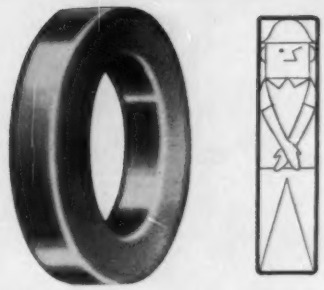
Arnold Tape-Wound Cores now offer you every feature you've been looking for

...at no added cost to you



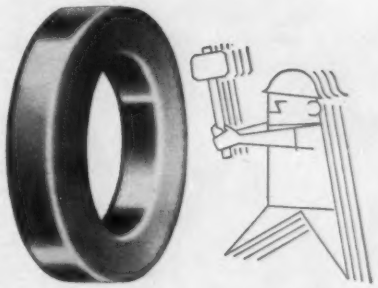
1 NEW COMPACTNESS in Aluminum-cased Cores

Now you can build your designs around the last word in improved tape cores of high-permeability materials. Arnold 6T Cores incorporate a new type of aluminum core box construction, with overall dimensions smaller than older types of aluminum cases, and comparable in size with ordinary plastic-cased cores. *Result:* along with the distortion-free strength of the aluminum case, that resists winding stresses, you now get the compactness and miniaturization possibilities you've wanted.



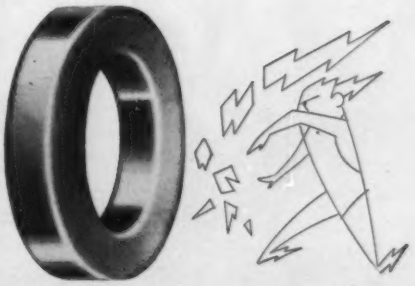
2 HERMETICALLY SEALED, with Built-in Protection against Shock and Vibration

Magnetic properties of Arnold 6T Cores have the most complete protection available on the market. The cores are surrounded by an inert shock absorbent inside the cases, and then hermetically sealed: your best assurance of trouble-free performance, a strong consideration where the service involves long periods of standby. Inherent in the design, of course, is the further guarantee that you can vacuum-impregnate your coils.



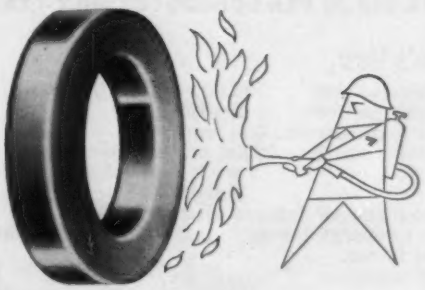
3 1000-VOLT BREAKDOWN GUARANTEED!

The revolutionary new type of core box construction developed for Arnold 6T Tape Cores employs a strong, inert covering for which 1000-volt breakdown is guaranteed. This covering possesses a hard gloss finish, and gives a suitable radius on all corners. The elimination of sharp corners insures against cutting through the insulation of the winding wire. The hard, non-cold-flowing finish protects against the wire cutting through the case covering, a double guarantee against shorted wiring.



4 MEETS MILITARY "SPECS" for Operating Temperatures and Temperature Rise

Arnold's new type of hermetically-sealed aluminum core box construction fully meets the requirements of military specifications Mil-T-5383 or Mil-T-7210, wherever applicable. This involves a positive guarantee that the case construction will withstand ambient temperatures to 170°C, and a 25°C temperature rise.



Arnold 6T Tape Cores will be available in all standard sizes, and special sizes may be made to order... all guaranteed for size, hermetic seal, dielectric strength and temperature of operation.

WSW 7250

THE ARNOLD ENGINEERING COMPANY

Main Office & Plant: Marengo, Illinois

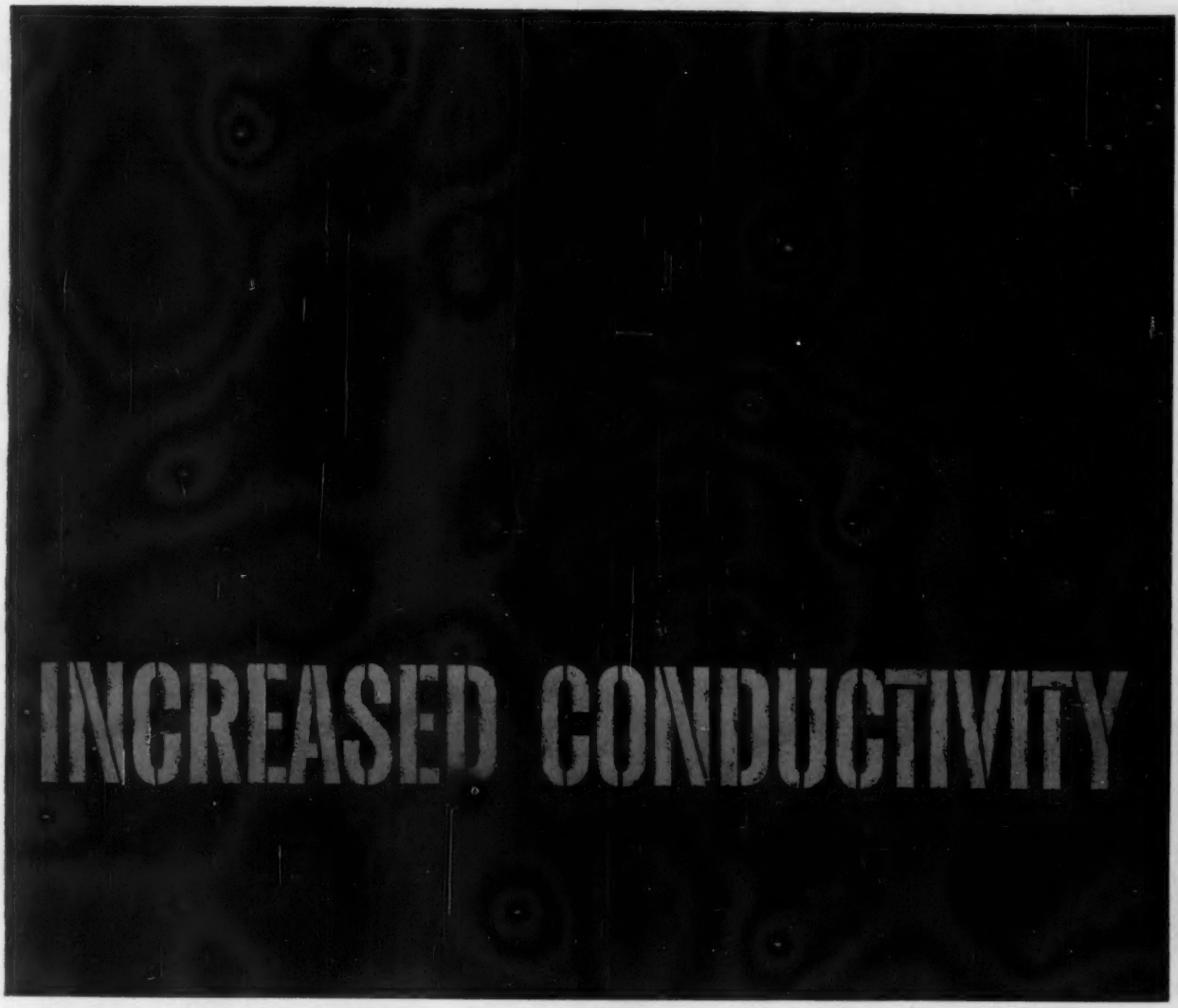
Repath Pacific Division Plant: 641 East 61st Street, Los Angeles, Calif.

District Sales Offices:

Boston: 49 Waltham St., Lexington Los Angeles: 3450 Wilshire Blvd.

New York: 350 Fifth Ave. Washington, D.C.: 1001-15th St., N.W.

For more information circle 18 on reader service card.



SAVE $13.30 PER CONDUCTOR MILE PER YEAR WITH NEW ALCOA 62.0% CONDUCTIVITY CONDUCTOR

Here's How:

Conductor size: 795,000 cm ACSR 26/7
Weight per foot: 1.094 lbs
Peak load current: 500 amps
Demand charge: $200 per kw (average for company with both hydro and steam generation)
Annual cost of demand charge: 11%
Cost of energy losses: $0.0035 per kwh
Load factor: 50%
Loss constant: 2650 (Fig. 13-1, p. 1159, Standard Handbook for Electrical Engineers, 9th Ed.)
Operating temperature: 50° C
Interest rate: 4%
Amortization period: 30 years
Resistance per conductor mile, 61% conductivity: 0.1297 ohms
Resistance per conductor mile, 62.0% conductivity: 0.1280 ohms
Power loss per conductor mile for 61% conductivity:
$P_L = I^2 r_a = 500^2 \times .1297 = 32.43$ kw
Annual cost of demand charge per conductor mile:
$C_D = 32.43 \times \$200 \times .11 = \$713.46$

Annual energy loss per conductor mile:
$32.43 \times 2650 = 85{,}940$ kwh
Annual cost of energy losses per conductor mile:
$C_e = 85{,}940 \times \$0.0035 = \$300.79$

Total annual loss charges per conductor mile:	$713.46
	300.79
	$1,014.25

For 62.0% conductivity, annual loss charges per conductor mile are $1,000.95.
The annual saving between the two is $13.30 per conductor mile.
The present value of benefits is:

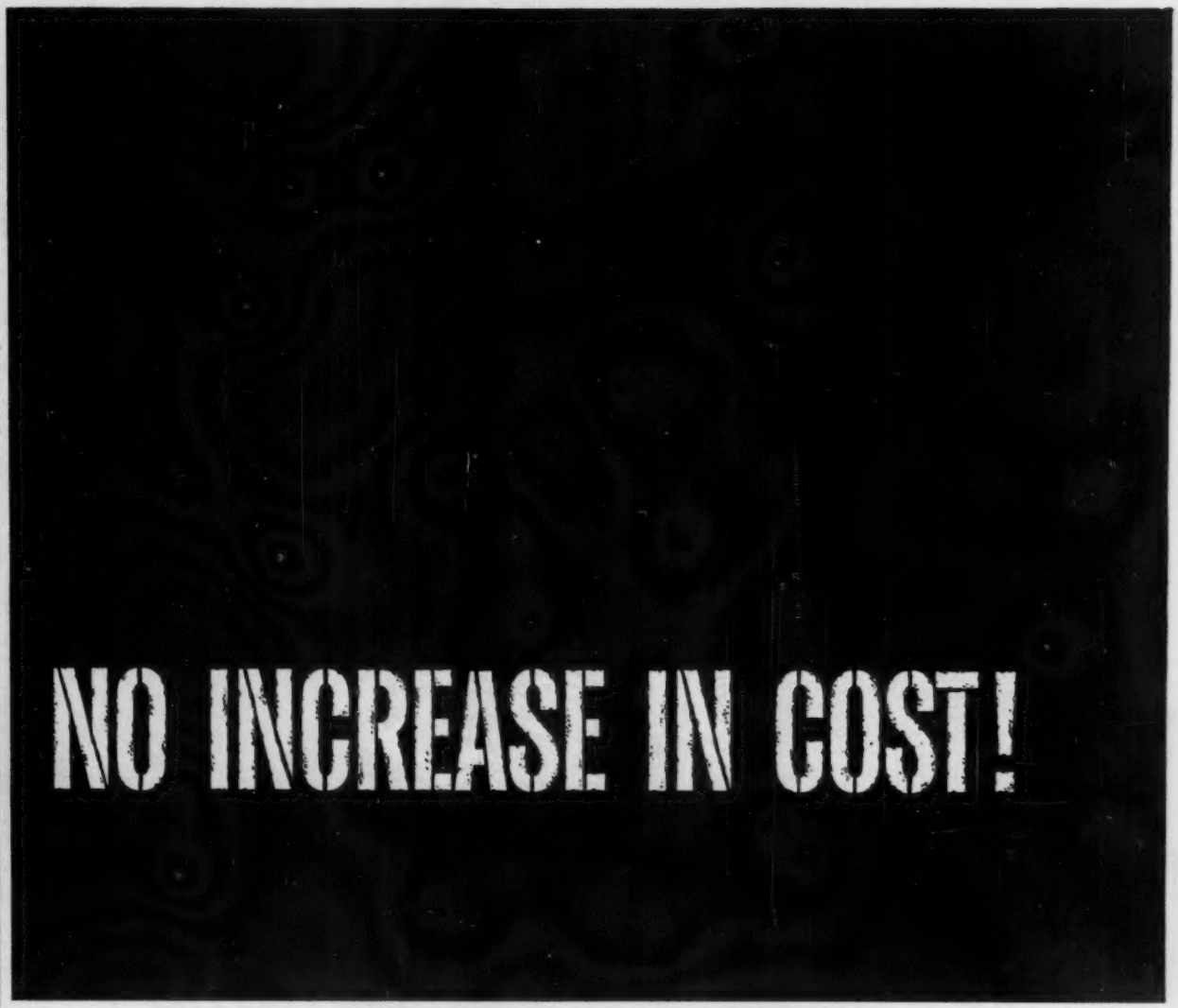
$$PV = C\frac{1-(1+r)^{-n}}{r}$$

$$= \$13.30 \times \frac{1-(1+.04)^{-30}}{.04} = \$229.96$$

Converted to per-pound value of conductor:

$$\frac{\$229.96}{5280 \times 1.094} = \$0.0398 \text{ per pound of conductor}$$

Note: This example is designed to show typical costs. Cost factors will, of course, vary for your area, resulting in smaller—or even greater—savings.



Here's Why:

Alcoa's new electrical conductor standard with minimum guaranteed conductivity of 62.0% IACS (International Annealed Copper Standard) can save you money *right now.*

This remarkable new Alcoa development in electrical technology gives you an increase in conductivity at no increase in cost over EC grades of conductor formerly supplied. Extensive shipments have already demonstrated the complete dependability of this new Alcoa high conductivity guarantee. If you *must* consider other sources for *either* transmission or distribution, ask for certified test reports.

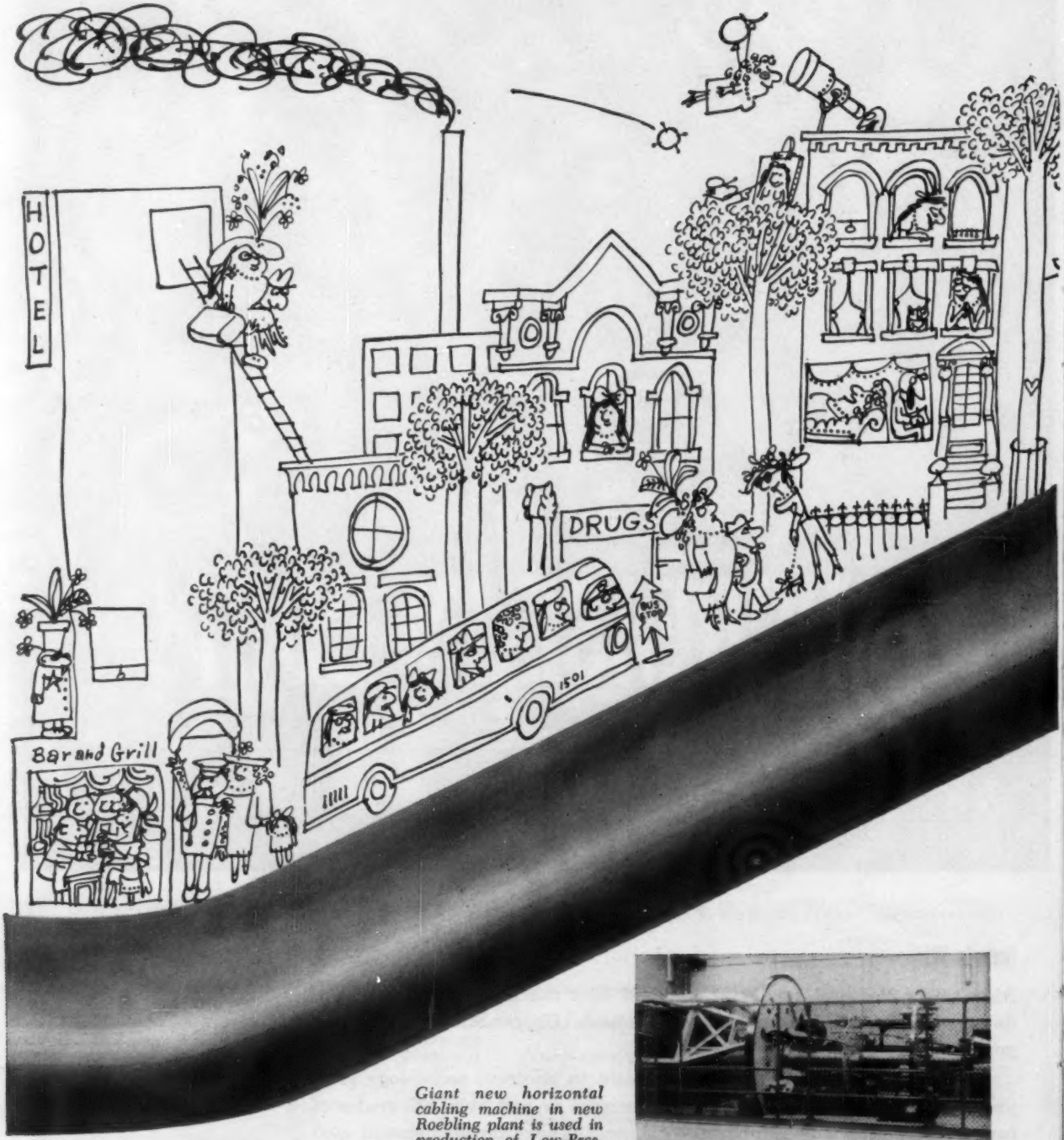
This new conductor is the latest example of Alcoa's leadership in research and development which for over half a century has produced increasingly efficient conductors and accessories for the nation's electric utilities. For more information on how Alcoa 62.0% conductivity conductor can result in savings on *your* system, call Alcoa. Aluminum Company of America, 2309-H Alcoa Building, Pittsburgh 19, Pennsylvania.

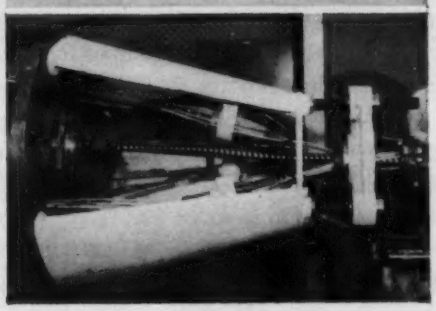
ALCOA ALUMINUM
ELECTRICAL CONDUCTORS AND ACCESSORIES
ALUMINUM COMPANY OF AMERICA

Your Guide to the Best in Aluminum Value

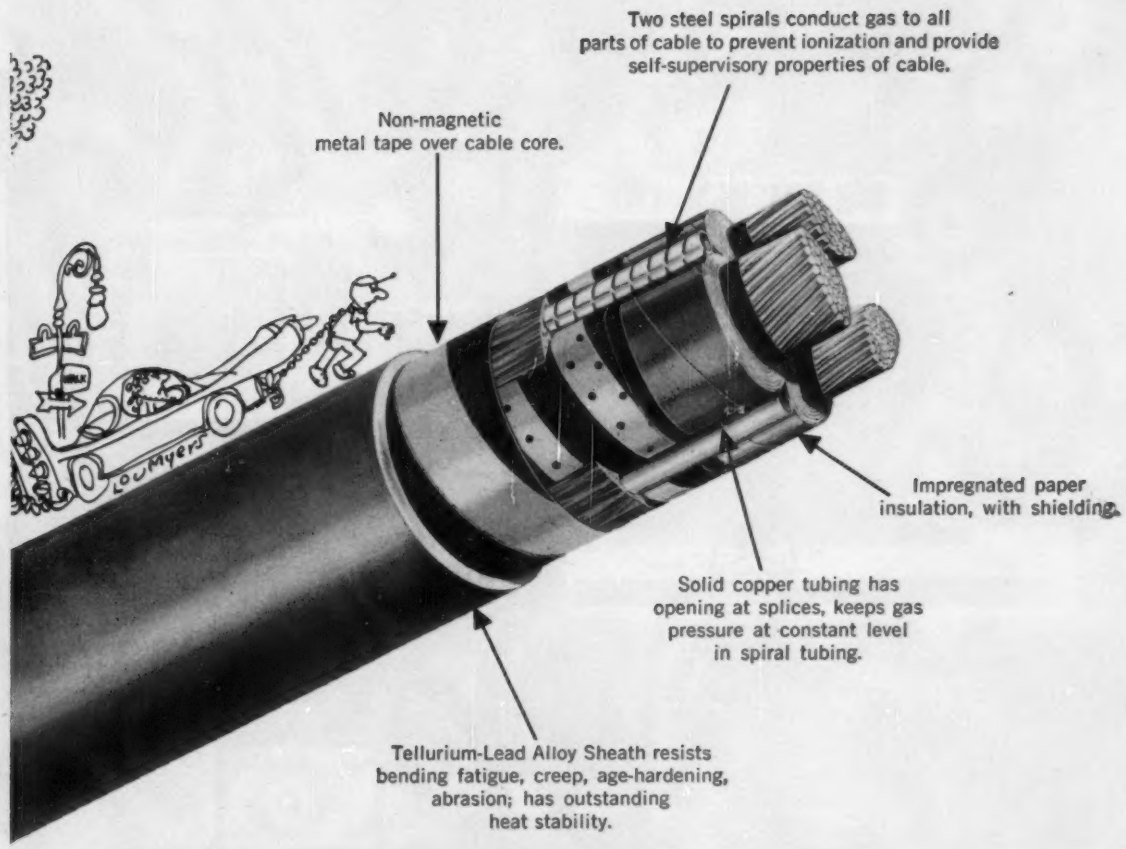
"ALCOA THEATRE"
EXCITING ADVENTURE
ALTERNATE MONDAY EVENINGS

For more information circle 19 on reader service card.





Giant new horizontal cabling machine in new Roebling plant is used in production of Low-Pressure Gas-Filled Cable. Here spirals, tube, insulated conductors and paper fillers are formed into cable.


Two steel spirals conduct gas to all parts of cable to prevent ionization and provide self-supervisory properties of cable.
Non-magnetic metal tape over cable core.
Impregnated paper insulation, with shielding.
Solid copper tubing has opening at splices, keeps gas pressure at constant level in spiral tubing.
Tellurium-Lead Alloy Sheath resists bending fatigue, creep, age-hardening, abrasion; has outstanding heat stability.
Lou Myers

FOR **UPHILL POWER** PROBLEMS **ROEBLING GAS-FILLED CABLE!**

Packs more power in less space than solid-type cable!

When power circuit profiles include steep grades, there's no better means of power transmission than *Roebling Low-Pressure Gas-Filled Cable!* Here's why. When a solid-type cable is used for an installation of this kind, its oil impregnant inevitably drains to the bottom of the grade. Result? At the top, the cable becomes vulnerable to ionization. And oil pressure build-up at the base of the grade rapidly causes a rupture in the lead sheath, resulting in cable failure.

Roebling Low-Pressure Gas-Filled Cable (for voltages up to 46 kv) ends both these problems . . . and has other benefits besides! Dry nitrogen gas, inside the cable at approximately 12 psi pressure, effectively suppresses ionization. From the top of the grade to the bottom, internal pressure is uniform.

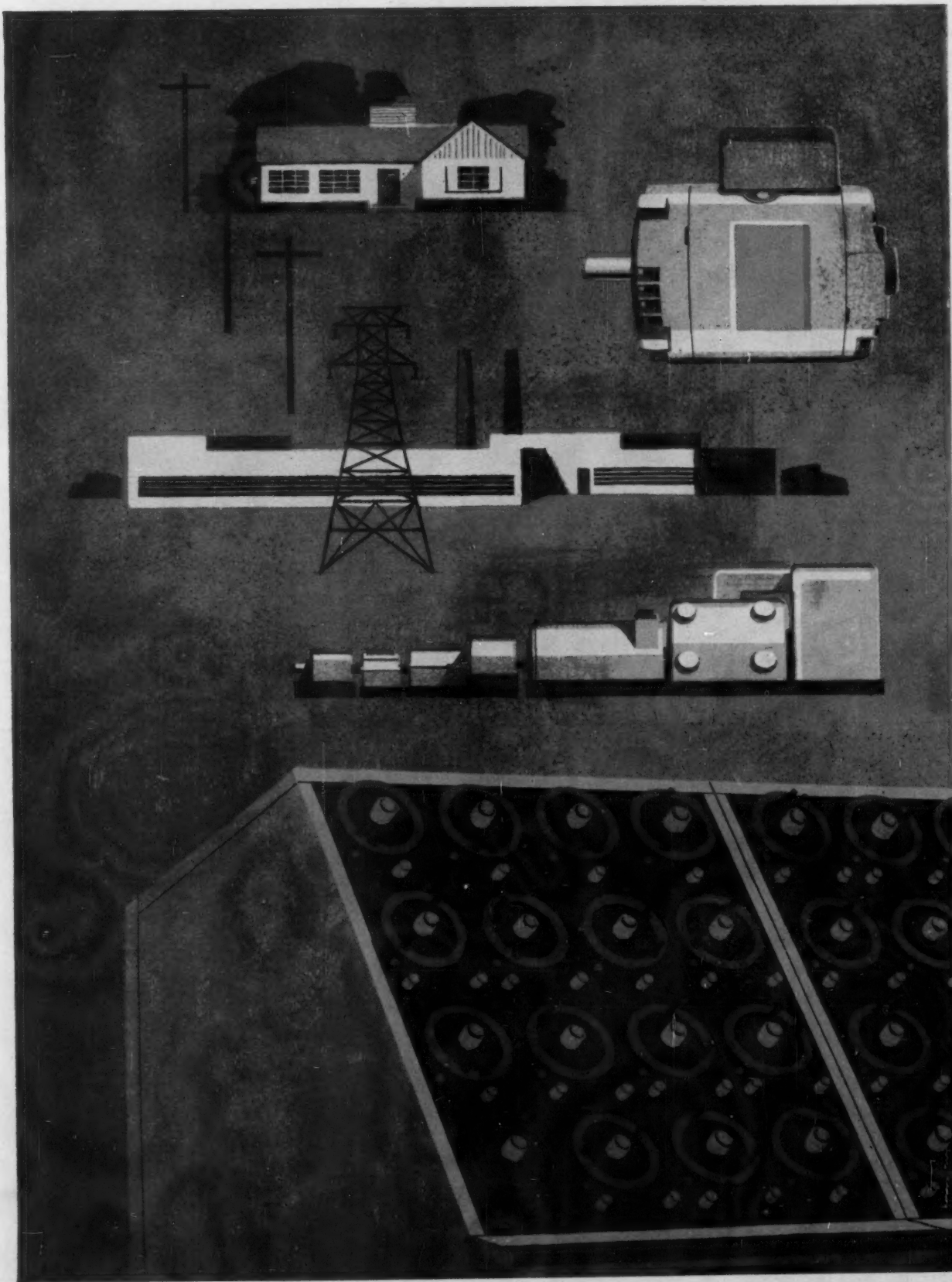
Another major advantage of Roebling Gas-Filled Cable is that it is self-supervisory. An alarm system immediately tells you if there's trouble along the line. And because this cable carries more power in a smaller diameter, existing manholes and conduits do not have to be altered.

If you have had trouble making power cable behave on grades (or anywhere else), call your Roebling Field Representative *today* about Roebling Low-Pressure Gas-Filled Cable! And for an eye-opening brochure, write Electrical Wire Division, John A. Roebling's Sons Corporation, Trenton 2, N. J.

ROEBLING

Branch Offices in Principal Cities • Subsidiary of The Colorado Fuel and Iron Corporation

For more information circle 20 on reader service card.



WESTINGHOUSE

AUTOMATIC DISPATCHING

Improves operation of your system • Reduces your generating costs

Building upon proven control techniques, Westinghouse has developed *new concepts* to make automatic power system control practical for *any size* utility. This new equipment has many unique features with unusual flexibility and is designed to meet the exact requirements of your system.

Savings with Westinghouse Automatic Dispatching System will quickly pay for this investment . . . with simplified dispatching to meet daily load schedules, automatically computing transmission losses and accurately maintaining tie-line pool operations.

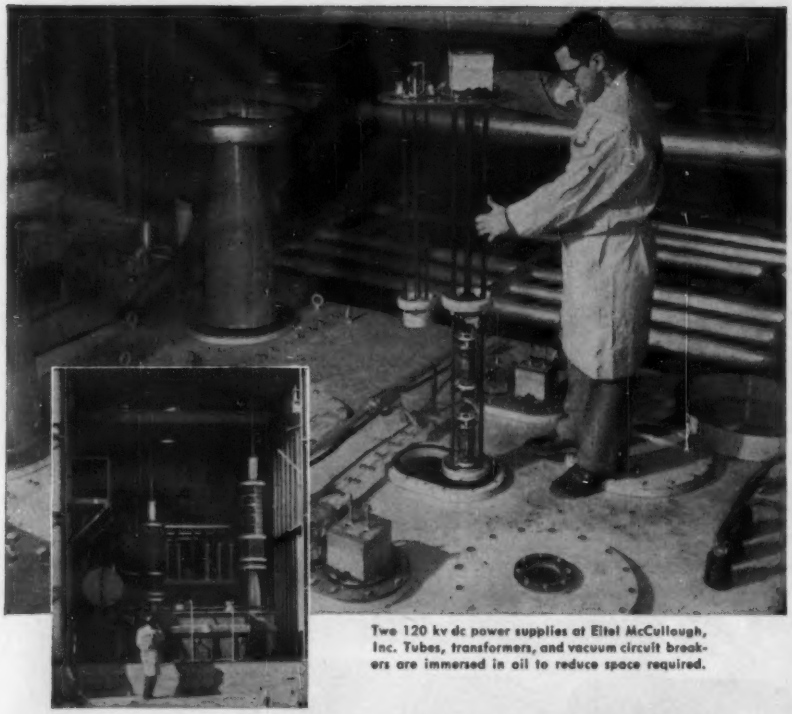
A Westinghouse Automatic Dispatching System brings you *modern* control for: improved economies, better intercompany relations, improved service and optimum use of tie-lines. Equipment continuously regulates generation to match system requirement, maintaining all machines in economic dispatch.

For information that can lead to more economical operation of your system, ask your Westinghouse sales engineer about the new Westinghouse Automatic Dispatching System. Or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. Ask for Folder B-7580. J-60960

YOU CAN BE SURE...IF IT'S Westinghouse

POWER CONTROL SYSTEMS

For more information circle 21 on reader service card.



Two 120 kv dc power supplies at Eitel McCullough, Inc. Tubes, transformers, and vacuum circuit breakers are immersed in oil to reduce space required.

WEST'S LARGEST DC POWER SUPPLY PROTECTED BY JENNINGS VACUUM RELAYS

This huge 240 kv dc power supply was built by Eimac to operate their large X626 Klystron tubes under test. During the processing of these tubes severe overvoltages are applied to insure thorough evacuation. The tube is protected from excessive arcing by Jennings fast acting overload circuit breakers.

Jennings overcurrent relays and vacuum switches are used in the secondaries wired for three phase simultaneous operation. Vacuum switches are also used for time delay back up protection in the 4160 primaries, to short out current limiting inductors, and to transfer the dc output for series or parallel operation.

Qualifications that made Jennings Overload Circuit Breakers the unanimous choice of Eimacs engineers are:

+ **High Speed Operation.** One-half to one cycle interruption including mechanical operate time.
+ **High Voltage Use.** Two type R9G vacuum switches in series require only 5/32 inch contact opening to interrupt 90 kv rms in this application.
+ **Maintenance Free.** Contacts sealed in a vacuum require no maintenance during the life of the switch.
+ **Non-explosive and Non-toxic.** Vacuum switches provide maximum safety to operating personnel.

Jennings Vacuum Circuit Breakers provide fast, reliable protection for dc power supplies when used in the primaries, the secondaries, or directly in the dc line. Write for catalog literature describing Jennings complete line of vacuum switches.

Jennings RADIO

Complete Overload Circuit Breaker Units are available composed of high voltage instantaneous trip overcurrent relay, a N/O vacuum relay, and a control box, any of which may be purchased separately.

JENNINGS RADIO MANUFACTURING CORP. • 970 McLAUGHLIN AVE. P.O.BOX 1278 • SAN JOSE 8, CALIF.

For more information circle 22 on reader service card.

New Products

(Continued from page 18A)

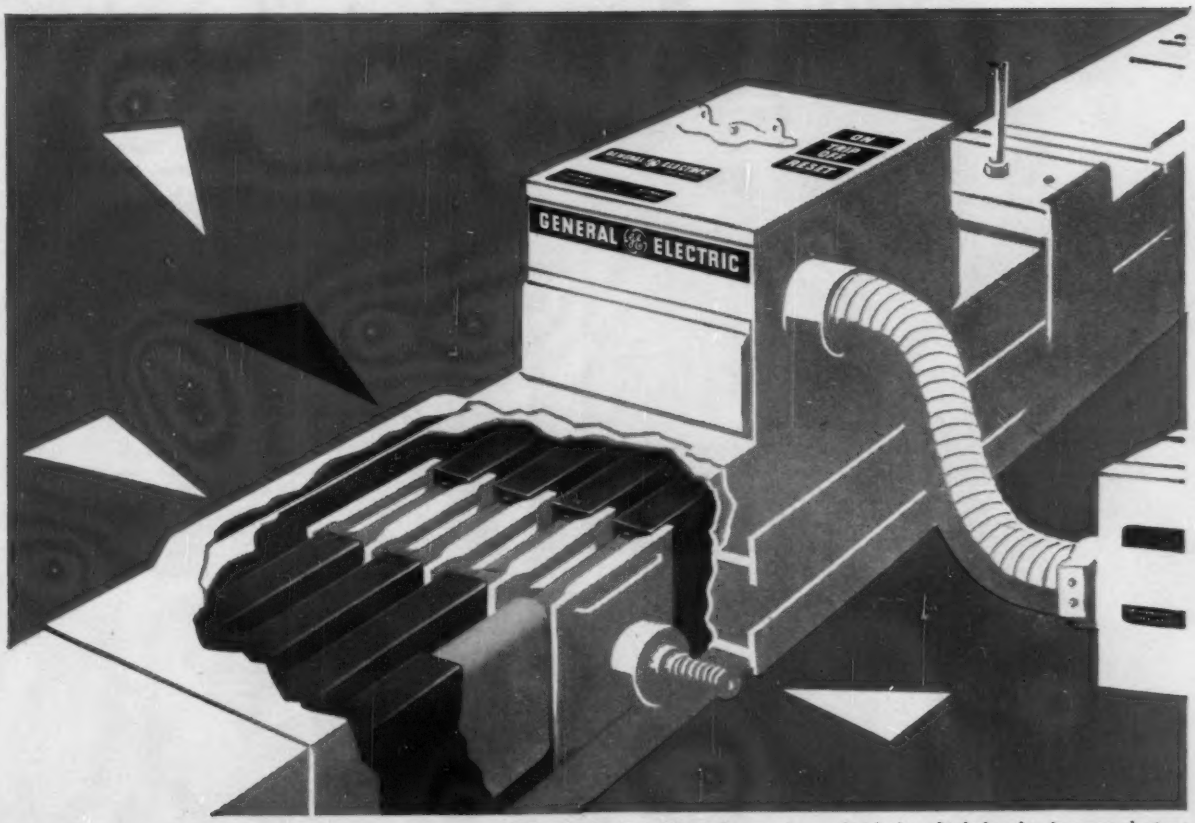
New Slide Attenuators. Development and availability of Series *825* and Series *835* slide attenuators has been announced. These slide attenuators are supplied with a finger-fitting knob that moves in a straight line and can be operated with a maximum pressure of 4 ounces. They are protected against dirt and foreign objects and supplied with slider-type terminals on rear. A removable side plate permits access to contacts. For additional information on these *825* and *835* slide attenuators write, E. L. Grayson, The Daven Company, 530 W. Mt. Pleasant Ave., Livingston, N. J. *Circle 209 on the card.*

Magic Marker. This writing and marking device fits neatly into the palm of the hand and requires no dipping or filling. Just lift the cap and write or mark indelibly on almost any surface, including glass, paper, wood, cloth, metal, acetate, and even on cellophane tape. Its special formula ink dries instantly and is waterproof and heat resistant. It writes with a

felt nib that makes lines of varied widths from pen stroke to brush stroke size depending upon which way the nib is turned. There is no danger of leakage or spills due to the patented "no loose ink" construction. The Magic Marker is available in nine bright colors, including black and white, plus four pastel shades. For further information contact the manufacturer, Speedry Products, P.O. Box 97, Richmond Hill 18, N. Y. *Circle 210 on the card.*

Hand-Light for Repairmen and Technicians. The *F-5P*, a powerful hand-light especially adaptable to the needs of repairmen and technicians, is announced by Carpenter Mfg. Co., Bradley St., Somerville 45, Mass. The light is of extremely rugged aluminum construction throughout and has a high-impact plastic lens which makes it ideal as a portable light subject to constant use, and the punishment of tool box or truck storage. It clamps to standard 7½ volt battery-packs. *Circle 211 on the card.*

(Continued on page 34A)



When Enjay Butyl is used as continuous insulation of tubular aluminum conductors, traveling arcs are virtually eliminated, plug outlets are essentially dead-front.

ENJAY BUTYL

helps keep costs low in new Aluminum Busway!

Enjay Butyl is extruded over the full length of the conductors used in General Electric's new Type DE Busway, the first busway designed specifically for aluminum. This new busway incorporates all 22 features that engineers consider important in busway design, yet it is up to 30% smaller and 50% lighter than other busways of comparable rating.

Enjay Butyl rubber is ideal for use as continuous insulation of tubular conductors because of its inherent resistance to ozone and to heat aging. Add Butyl's excellent electrical properties, its vulcanizability and the fact that it is the *lowest cost* rubber on the market—and you'll understand why it was chosen above all other rubbers to do this job.

Every day manufacturers are discovering new ways to use economical Butyl. Find out how Enjay Butyl rubber can cut production costs for you. For further information and expert technical assistance, contact the Enjay Company.

ENJAY BUTYL

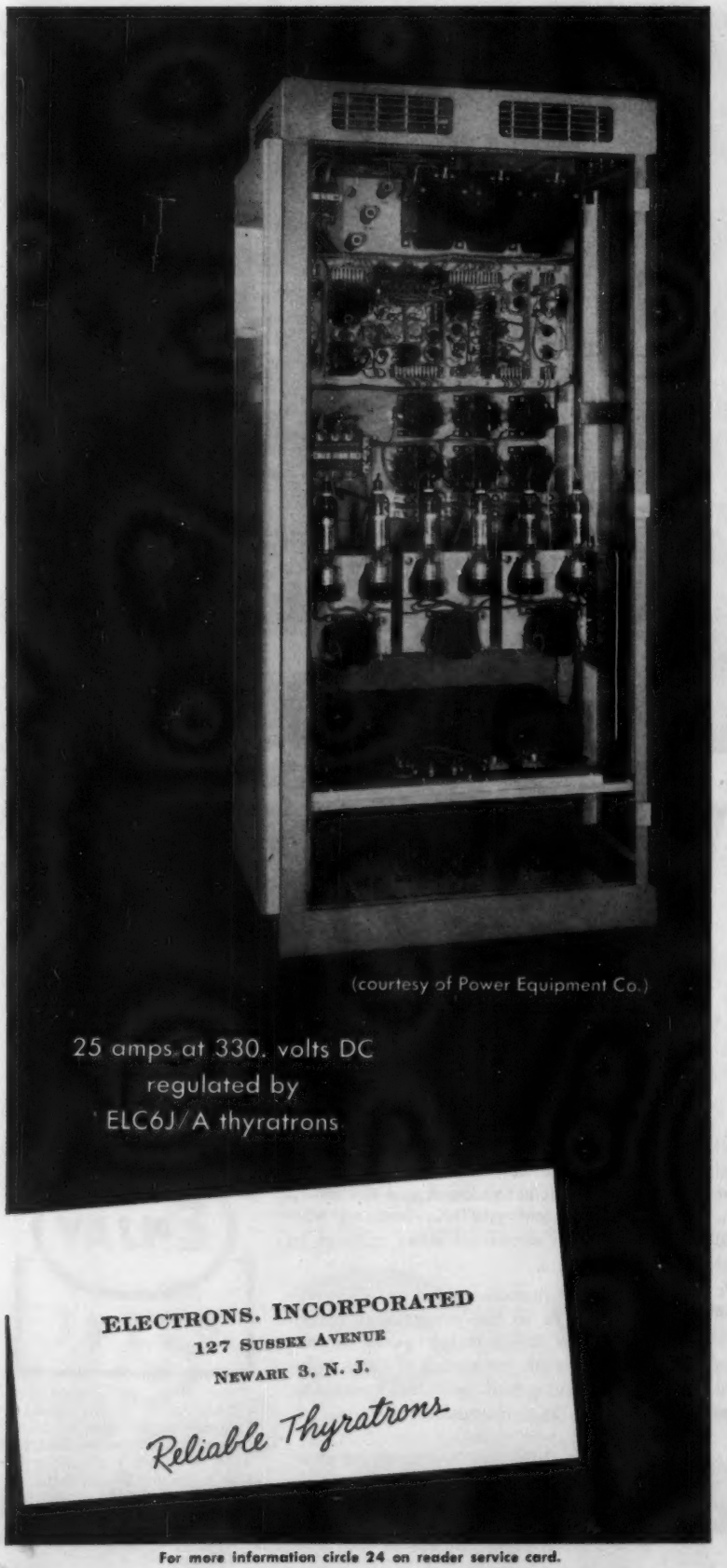
Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

For more information circle 23 on reader service card.



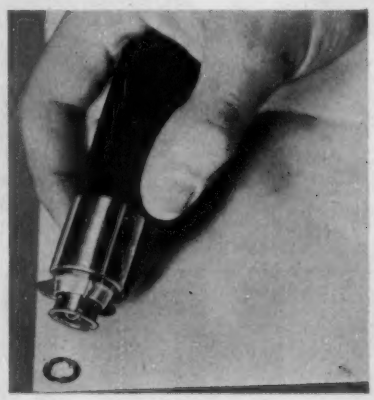
For more information circle 24 on reader service card.

New Products

(Continued from page 32A)

Liquid Flux for Silver Brazing. A true liquid flux, specifically developed for brazing silver, gold, platinum, and for numerous electronics applications, has been developed by the research laboratories of Eutectic Welding Alloys Corporation, 40-40 172nd St., Flushing 58, N. Y. It is called Eutec-Liquitor. Designed mainly for critical and delicate work, this flux gives the utmost in controlled application, visibility, and minimum residue removal. It is unique in that it can be very accurately applied with pipette, eye dropper, hypodermic needle, as well as automatic metering devices. *Circle 212 on the card.*

Tacking Device. A unique device that automatically places tacks and reclaims them for subsequent use has been introduced in this country. Called the Tack-N-Taker, this multipurpose instrument is ideal for fixing papers to drawing boards and for other drafting and architectural

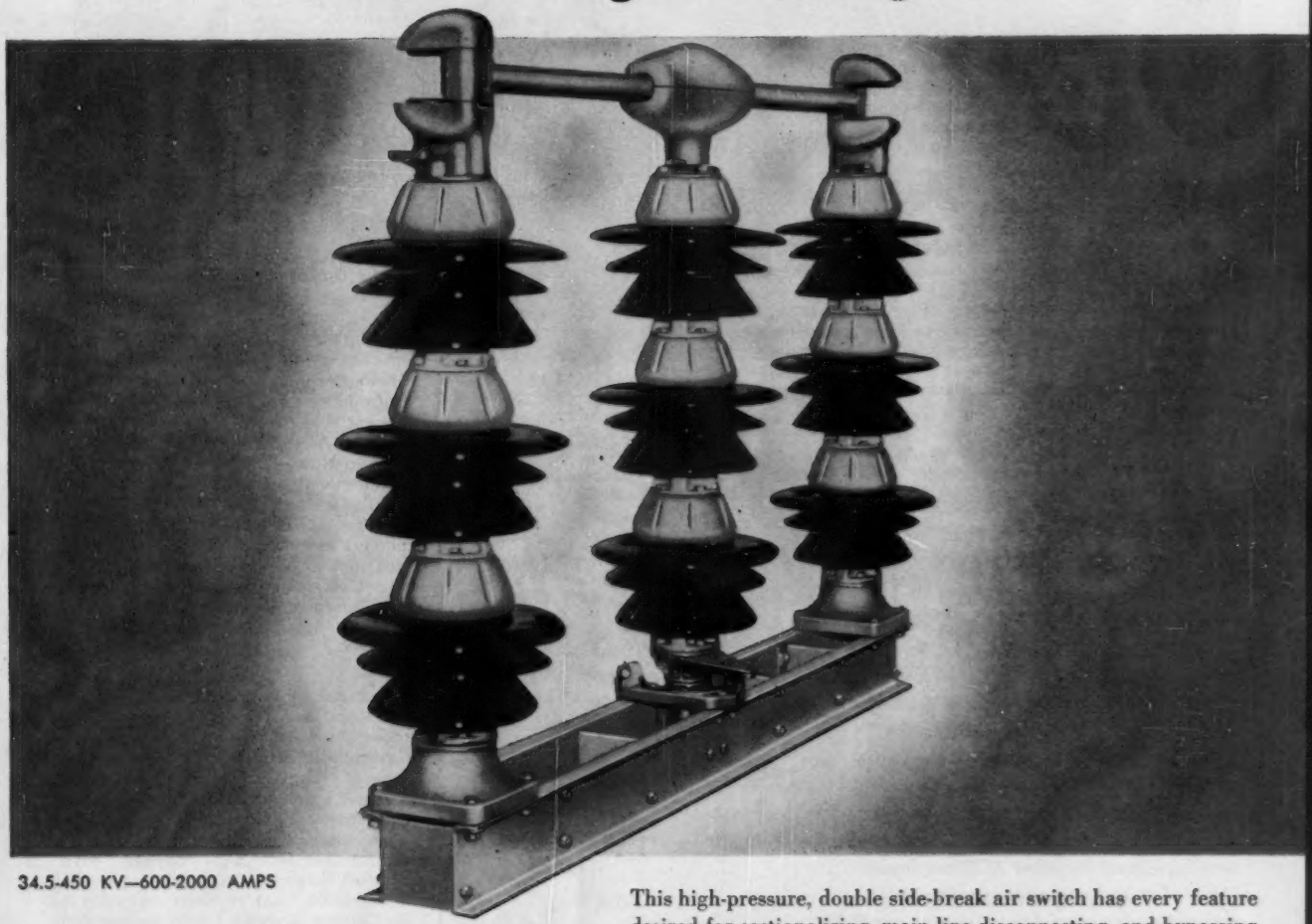


uses. Requiring only a push of the hand to tack or take, the compact precision engineered tool stores its own ammunition in an easily filled magazine. The 4-inch tubular device is designed for needs commonly filled by tacks, push pins, staples, tape, and similar contrivances. Further information on the Tack-N-Taker is available from colorFIX Import Co., 1409 Willow St., Minneapolis 3, Minn. *Circle 213 on the card.*

Subminiature Lamps in Standard Base. A line of subminiature lamps that may be used in the standard *T3¼* lamp base is announced by Industrial Electronic Engineers. This permits use of a smaller lamp than the standard No. *44* lamp which is normally used in the *T3¼* lamp base, especially where voltage, wattage, and convenience are factors, states the manufacturer. The subminiature lamp is permanently set in the adapter and the two become a single integral unit. When the lamp burns out, the adapter is discarded with the burned-out lamp. For more complete detailed information regarding these subminiature lamps with adapters, write direct to the manufacturer, Industrial

(Continued on page 36A)

Southern States' streamlined RDC offers 5 big advantages in design



34.5-450 KV—600-2000 AMPS

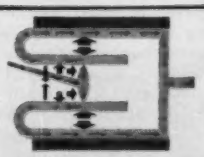


FIG. 1

CUTAWAY VIEW

Amplitact® Contacts on RDC

High pressure Amplitact contacts provide maximum dependability under high current short-circuit conditions. The arrows in Fig. 1 show direction and relative magnitude of electromagnetic forces induced when switch is subjected to fault current.

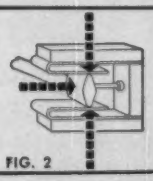


FIG. 2

The resultant ELECTROMAGNETIC forces, as shown by arrows in Fig. 2, greatly increase contact pressure and positively hold blade in engaged position.

This high-pressure, double side-break air switch has every feature desired for sectionalizing, main line disconnecting, and bypassing service in substations and on transmission lines. In addition the RDC has five outstanding advantages in its design:

1. Low silhouette in the open position permits application where vertical clearance prohibits the use of vertical-break switches.
2. Switch blade is completely dead in open position. Phase spacing is less than required for single side-break switches.
3. Horizontal breaking permits lower zone of protection against lightning, with corresponding savings in steel structures.
4. Smooth, corona-resistant contours result in RIV of less than 500 microvolts.
5. One-piece blade is balanced in all positions, reducing stress on moving parts. No blade balancing mechanism is required.

Your Southern States representative will be glad to give you complete details. Or write direct for Bulletin 57 RDC.

LIVE BETTER ELECTRICALLY

SOUTHERN STATES
EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

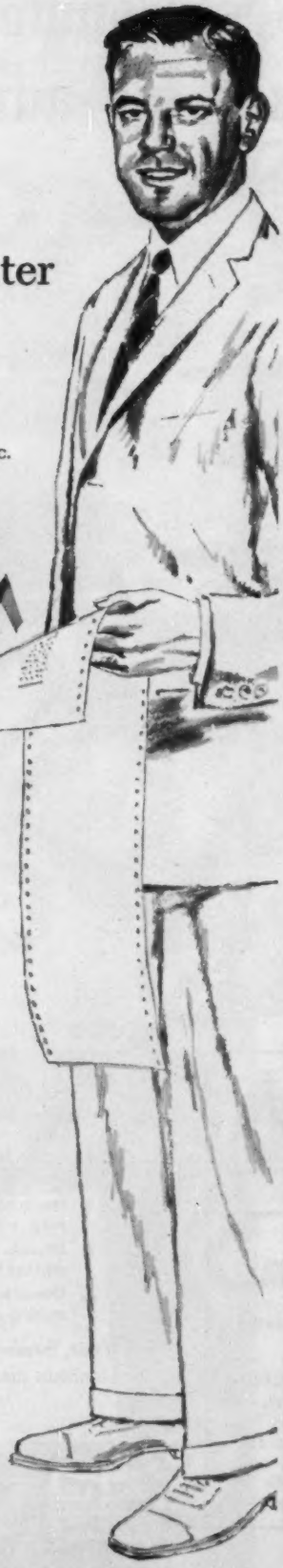
"We taught ourselves

to use the

Bendix G-15 computer

...it's that easy."

PETER M. LANG, *Senior Engineer*
NUCLEAR PRODUCTS—ERCO DIVISION OF ACF INDUSTRIES, INC.



"Our nuclear engineering staff, in developing commercial power reactors, required a full-sized digital computer that the entire group could use. We picked the G-15 and I was first to learn its use. I taught myself in two days without help and in turn taught two-day classes for other ACF employees. Many of us had no previous computer experience, but we are now keeping our G-15 'hopping'—often seven days a week and eight to twelve hours a day."

THE G-15 GIVES YOU memory and speed of computers costing four times as much • Typewriter input-output, paper tape output and 250 characters/sec paper tape input at no added cost • Punch card input-output available • Extensive library of programs furnished • Strong user's sharing organization • Proven reliability • Nationwide sales and service • Lease or purchase.

Bendix® Computer

DIVISION OF BENDIX AVIATION CORPORATION

Built and backed by Bendix, the G-15 is serving scores of progressive businesses large and small throughout the world. For details, write to Bendix Computer, Department K-4 Los Angeles 45, California.

For more information circle 26 on reader service card.

New Products

(Continued from page 34A)

Electronic Engineers, 3973 Lankershim Blvd., North Hollywood, Calif. *Circle 214 on the card.*

Portable Dehumidifier. A portable room dehumidifier on wheels has been announced by Suttle Equipment Corporation which effectively removes 2 to 3 gallons of water from the atmosphere every 24 hours, suitable for industrial or home use. Write Suttle Equipment Corporation, 135 S. LaSalle St., Chicago 3, Ill., for full details and prices. *Circle 215 on the card.*

Panelescent Lamp. A dial-in-the-dark telephone utilizing a Panelescent lamp has been announced by Sylvania Electric Products Inc. The telephone is being produced by Automatic Electric Company, the manufacturing subsidiary of the General Telephone Corp. The Panelescent lamp is the Sylvania device which produces light over the entire surface of a panel by the principle of electroluminescence, the creation of light through the excitation of certain phosphors placed in an electric field. Only 0.025 of an inch thick, the lamp produces a uniform light without the use of bulbs, tubes, filaments, or cathodes. Its construction consists of a porcelainized steel sheet with a ceramic-phosphor coating. For further information contact Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y. *Circle 216 on the card.*

Sound Barrier Noise Protector. The No. 258 Sound Barrier provides personal noise protection for personnel in industrial and Government installations where high-level noise is a factor. The Sound Barrier is an ear-muff type noise protector that is compact, light-weight, and fully adjustable while providing dependable protection against harmful high-frequency noise. Comfort is assured the wearer by patented, liquid filled vinyl cushions developed by the Willson Research Center so that there is a constant, sound-tight fit even when the person wears glasses or safety spectacles. The cushioning effect of the liquid filling, plus the polyurethane sponge inside each cup, obsoletes old-style solid material cushions. In addition, the scientifically shaped thermosetting malamine cups with front and back fit, are engineered for efficient noise deflection. For further information contact Willson Products Division, Ray-O-Vac Company, 212 E. Washington Ave., Madison 10, Wis. *Circle 217 on the card.*

Snap Action Switch. The Melematic, a new snap action switch, is now available for users, manufacturers, and designers. This switch is built to meet the rigid standards for high quality equipment. These are suitable for use where the operating force is specific. Design characteristics include exact repeatability and stability in temperature and humidity conditions. It conforms to the dimensional requirements of military standard *MS 25026*. The switch has the Underwriters'

(Continued on page 40A)

Courtesy Mount Wilson Observatory

FROM BEYOND THE SKY TO BENEATH THE SEAS

In the field of communications, two extraordinary events have occurred within a short span of time. One was the linking of Europe to America by the submarine telephone cable. The other was the sending of radio signals from U. S. satellites in outer space.

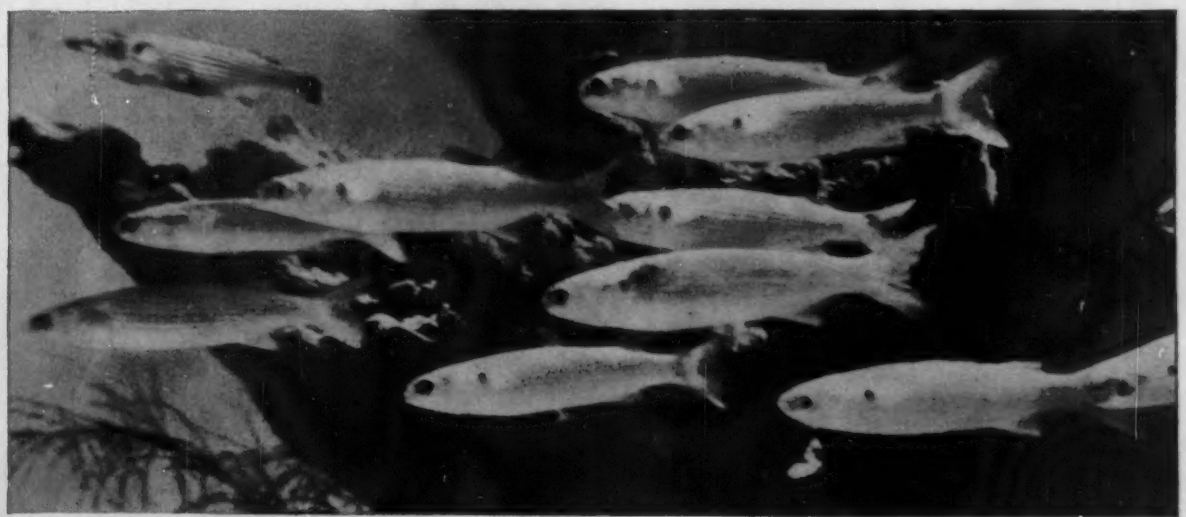
Both achievements depended on developments from Bell Telephone Laboratories. The cable was made possible by development of long-life electron tube amplifiers able to withstand crushing pressure on the ocean floor. The satellites derive their radio voices from transistors—products of basic research in semiconductor physics.

The deep sea amplifier and the transistor illustrate the wide range of work at Bell Telephone Laboratories. Here, over 3000 professional scientists and engineers explore and develop in physics, mathematics, electronics, chemistry, mechanical engineering, even biology—in every art and science which can help improve electrical communications.

Through this work, Bell Telephone Laboratories has helped make your telephone service the world's finest—and will keep it so.

BELL TELEPHONE LABORATORIES

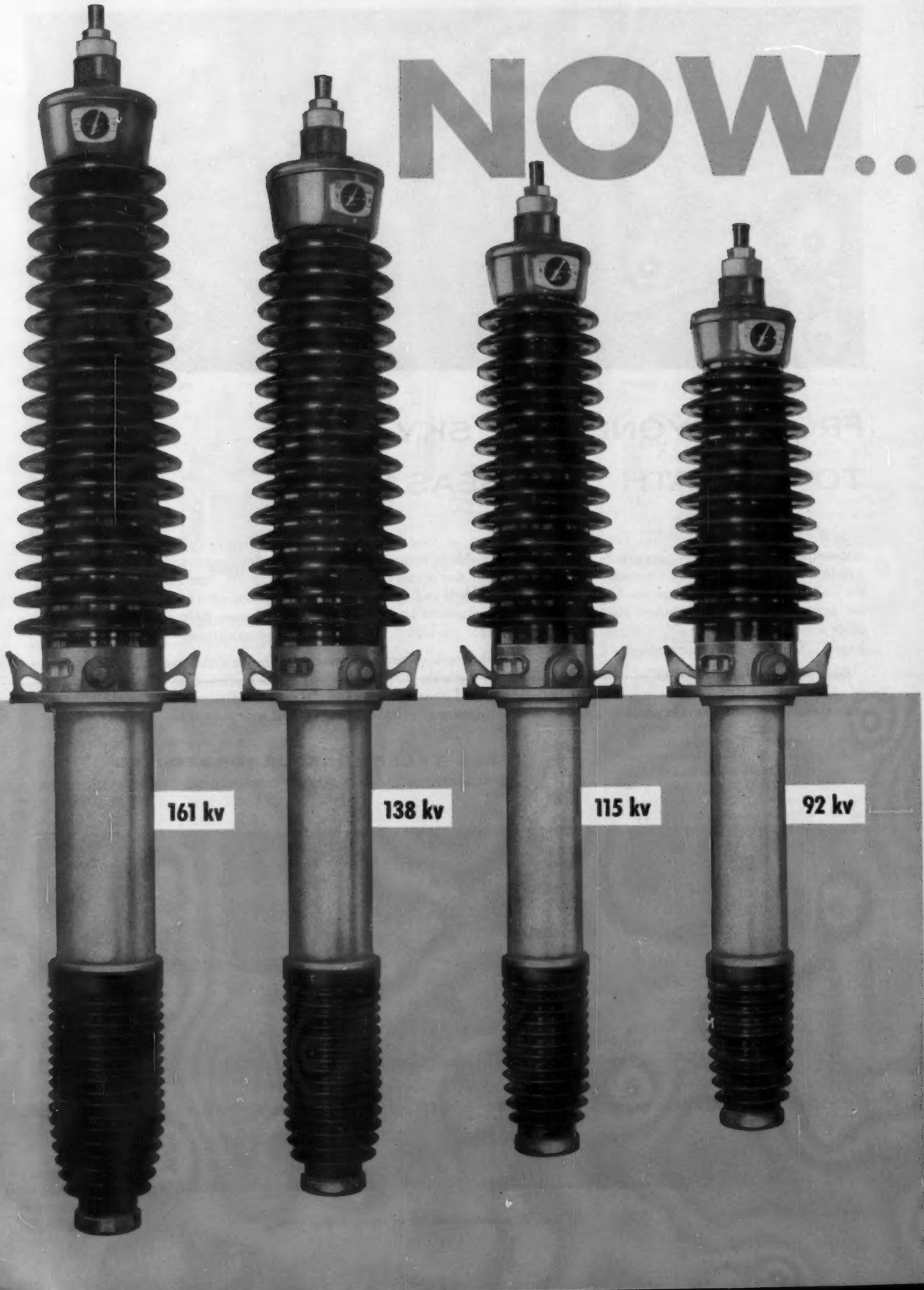
WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



Circle 28 ▶

For more information circle 27 on reader service card.

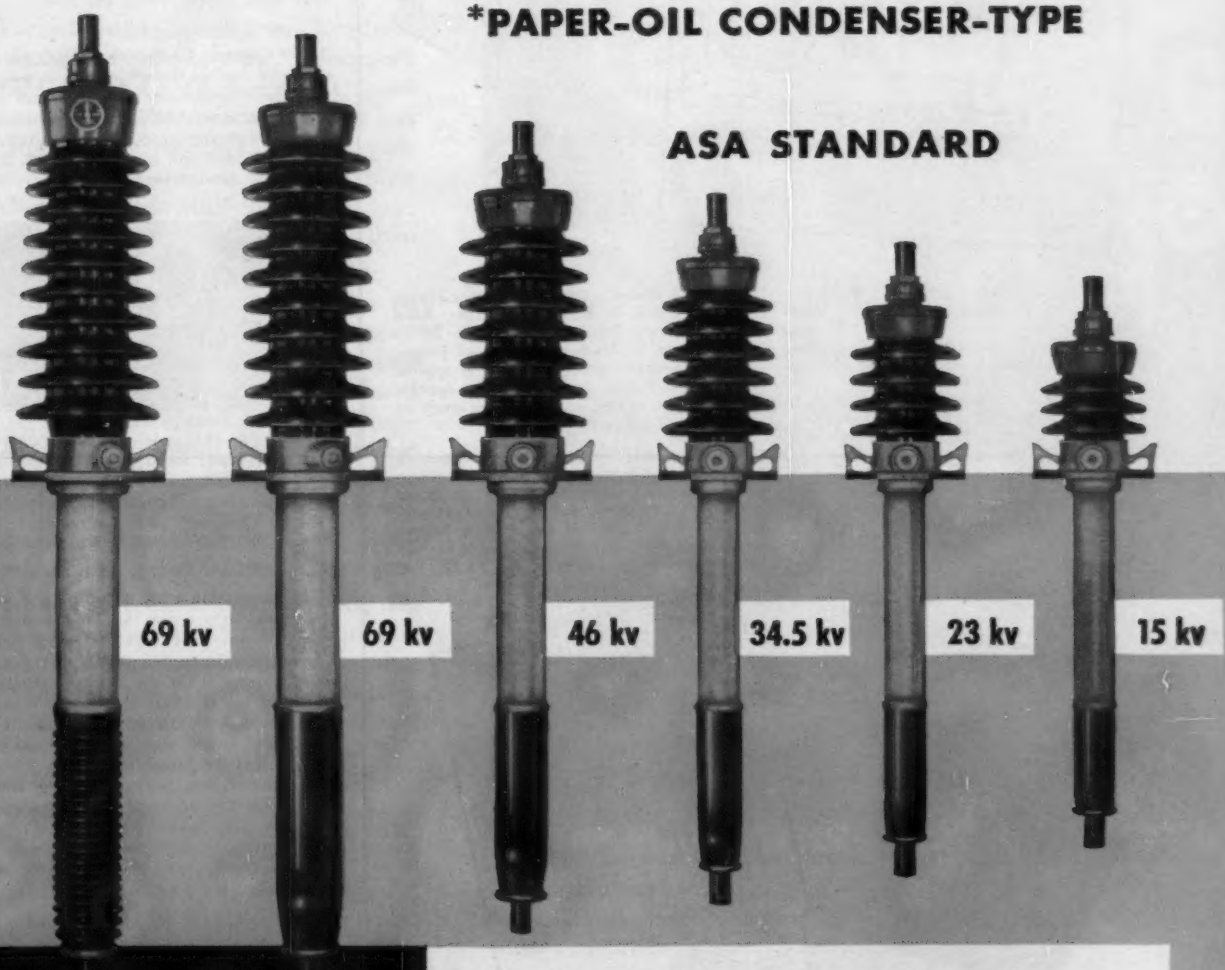
NOW..



Lapp POC* Bushings
in voltage ratings to 161 kv

*PAPER-OIL CONDENSER-TYPE

ASA STANDARD



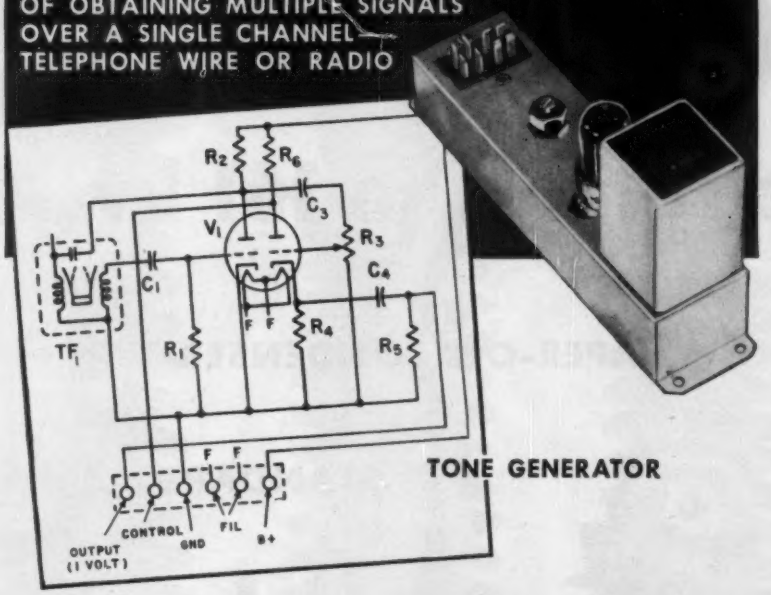
Lapp

At every voltage rating from 15 kv up, Lapp POC* Bushings provide the operating security of totally-enclosed design...
...all exposed insulation is *porcelain.*

Lapp Insulator Co., Inc., Le Roy, N. Y.

BIDDLE TONE SIGNALLING EQUIPMENT ...Packaged Circuits

A LOW COST, FLEXIBLE MEANS OF OBTAINING MULTIPLE SIGNALS OVER A SINGLE CHANNEL— TELEPHONE WIRE OR RADIO



TONE GENERATOR

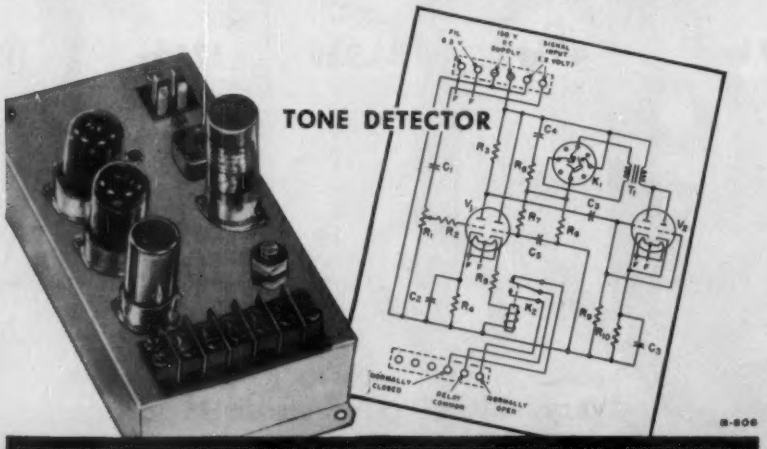
These complete tone generator and tone detector circuits, employing Frahm® Resonant Reed Oscillator Controls and Relays, are available as veritable "building blocks" for your communications system.

Applications for these packaged circuits include: selective calling, remote operation, supervisory control, data transmission, telemetering, and monitoring.

The Tone Generators are complete packaged oscillator circuits capable of supplying any one signal frequency within the ranges of 20 to 250 cps or 250 and 1100 cps, with accuracy of ±0.15%.

The Tone Detectors or receiving circuits, which employ a Frahm Resonant Reed Relay, operate the contacts of the SPDT relay in the unit when a signal of proper frequency and voltage amplitude is applied to the circuit input terminals. They operate with signals having any one frequency in the range of 20 to 1000 cps.

We particularly encourage your inquiries and correspondence on special applications and problems. Complete details on these packaged circuits as well as specifications, characteristics, etc., of our Frahm Relays and Oscillator Controls are available for the asking. *Request Bulletins 33 and 34-EE.*



TONE DETECTOR

B-606

JAMES G. BIDDLE CO.

Electrical Testing Instruments • Speed Measuring Instruments
Laboratory & Scientific Equipment
1316 ARCH STREET, PHILADELPHIA 7, PA.

For more information circle 29 on reader service card.

New Products

(Continued from page 36A)

Laboratory seal of approval. For further information write Meletron Corporation, 950 N. Highland Ave., Los Angeles 38, Calif. *Circle 218 on the card.*

Safety Eyewear. Two-tone *S-7* shape plastic safety frames in jet black or rich brown combined with crystal clear plastic are modern and good-looking. They are available with matching color spatula or comfort cable temples, also with the original and exclusive flat-fold sideshields which attach permanently to the temples to permit folding flat. Write for information to United States Safety Service Company, 1535 Walnut St., Kansas City 8, Mo., or contact branch office in principal industrial cities. *Circle 219 on the card.*

Taper-Contact Connector. Taper-pin receptacles replace the solder-pots in a newly developed miniature, environmental electrical connector. This taper-contact connector meets or exceeds the requirements of MIL-*C-5015* and is available in 3, 7, 12, 19, 27, 37, and 61 contact arrangements.

All plugs in this series are available with the push–pull locking mechanism. For complete information on the taper-contact miniature electrical connector, contact The Deutsch Company, 7000 Avalon Blvd., Los Angeles 3, Calif. *Circle 220 on the card.*

Field Conversion Kits. A simple and compact field conversion kit for installing push button and selector switch pilot controls on Furnas Size 0, 1, and 1¼ magnetic starters is on the market. Designed for easy installation, these kits contain push-button or selector-switch unit with three-color coded lead wires, one pair of spring clips for attaching a push button, and easy-to-follow instruction sheet showing wiring diagrams and basic steps to installation. Information and prices on these field conversion kits can be obtained by writing the Furnas Electric Company, 1063 McKee St., Batavia, Ill. *Circle 221 on the card.*

Self-Regulating Distribution Transformer. Development of this transformer has been disclosed by Line Material Industries. Designated *SRT*, the new transformer has been designed to improve electric service and increase consumer satisfaction. It senses voltage at the utilization level and maintains an average secondary voltage of 120 volts by actuating a tap changer

(Continued on page 42A)

Specify Clampmatic® control

—to give your customers absolute switching security

For quick-make, quick-break action . . . *absolute switching security* . . . you can't beat BullDog's Clampmatic Control switch unit. Featured in BullDog bus plugs, safety switches, power panels and switchboards, it meets today's electrical needs with more efficiency, less maintenance, greater safety than any other available switching unit.

The exclusive Clampmatic action on line and load jaws doubles the pressure on the movable contact slug. It assures bolt-tight electrical contact when closed . . . and accelerated break when de-energized. The result is cooler operation which provides long and trouble-free switch life. In addition, the Vacu-Break enclosing head smothers arcs, minimizes pitting and burning of contacts.

Give your clients positive switching security with BullDog Clampmatic control. For complete details consult your electrical distributor or BullDog field engineer or write BullDog direct.

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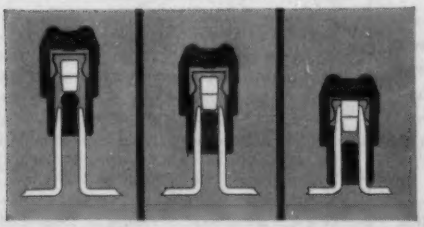


"Off" position; switching to "on"; "on" position—Clampmatic Control assures bolt tight contact, quick-break action. Circuits open with minimum arcing.

The BullDog field engineer demonstrates large scale model of Clampmatic action shown at left. Clampmatic-controlled switch units include (top to bottom): Vacu-Break Bus Plug, Safety Switch and units for switchboards and panelboards.

BULLDOG

BullDog Electric Products Company, Division of I-T-E Circuit Breaker Company, Detroit 32, Mich. *BullDog Export Division:* 13 East 40th Street, New York 16, New York. *In Canada:* BullDog Electric Products Co. (Canada) Ltd., 80 Clayson Rd., Toronto 15, Ont.

HEAT BETTER ELECTRICALLY

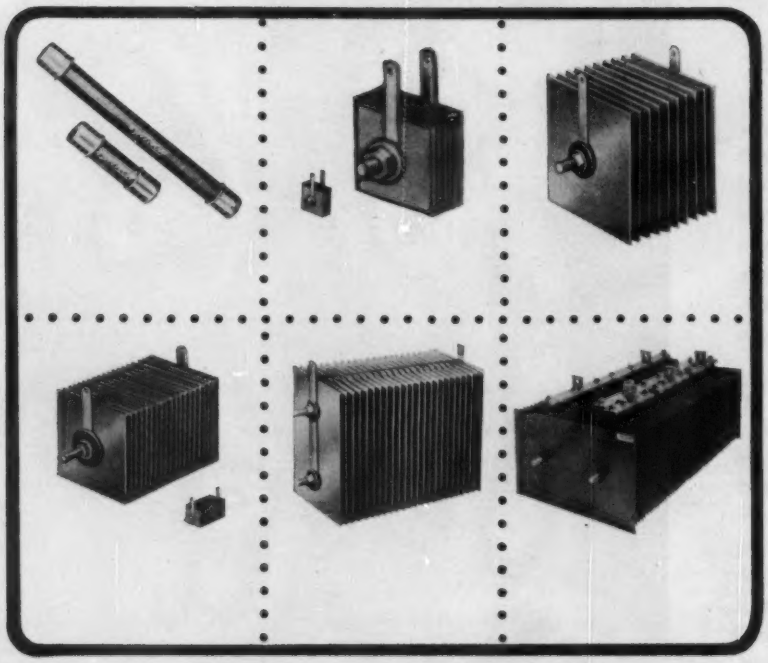
SYNTRON

Vacuum Process

SELENIUM RECTIFIERS

for all your d-c needs

. . . the widest range of cell sizes in the industry



SYNTRON SELENIUM RECTIFIERS FEATURES:

- High short circuit surge-current ability to 300 times normal rating
- Withstand high transient conditions without damage
- Cell voltage ratings from 15 to 45 volt RMS means fewer cells per stack
- Protection available for all atmospheric conditions alkaline or acid
- Constructed to withstand high amplitude vibrations

LONGER LIFE TEST PROVES LOWEST AGING, HIGHEST OUTPUT RESULTS IN LONGER LIFE FOR SYNTRON RECTIFIERS.

SYNTRON Selenium Rectifiers consistently outperform and out-last similarly rated rectifiers. Adequate, long lasting circuit control of SYNTRON Selenium Rectifiers is accomplished in the design stages, not by replacement.

SYNTRON Selenium Rectifiers are noted for these exceptional characteristics—lowest voltage drop, lowest leakage current, lowest temperature rise, longest life, greater uniformity from cell to cell and greatest voltage ratings.

E 558

Other SYNTRON Products of Proven Dependable Quality

● SELENIUM RECTIFIER UNITS ● ELECTRIC HEATING PANELS ● SINUATED WIRE
● ELECTRIC HEATING ELEMENTS ● PARTS FEEDERS

Write for complete information on all SYNTRON Products

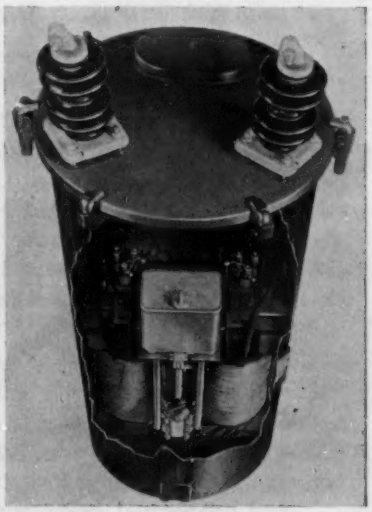
SYNTRON COMPANY
440 Lexington Avenue Homer City, Penna.

For more information circle 31 on reader service card.

New Products

(Continued from page 40A)

connected to the primary winding. Regulation is accomplished by automatically changing the transformation ratio in 2½% steps over a voltage range of 10%. Effective band width is 3½ volts centered around a base voltage of 120 volts. With respect to rated primary voltage, the regulation range of 10% can be manually selected to be from 90% to 100%, from 95% to 105%, or from 100% to 110%. Voltage ratings of the first *SRT's* range from 2,400 to 14,400, inclusive. Kva ratings



are 10 through 100. Operating features of *SRT's* include a time delay which prevents hunting and unnecessary responses to momentary voltage fluctuations, and temperature compensation which provides reliable operation of the sensing mechanism over a temperature range of —40C to +150C. The self-regulating mechanism requires only 12 watts for its operation. *Circle 222 on the card.*

High-Voltage Insulating Oil Tester. A high-voltage tester, Model *4505* HYPOT, for testing breakdown of all insulating liquids is announced by Associated Research, Inc. This new HYPOT is designed to test insulation liquids such as transformer oil to meet American Society for Testing Materials (ASTM) and Federal specifications. This oil tester is of value to production and maintenance engineers working with high-voltage equipment employing insulating oils such as transformers, high-voltage capacitors and bushings, or oil-immersed components or power supplies. The features incorporated into this instrument include ample voltage range, 0 to 35 kv a-c, 2 kva capacity rating to meet ASTM and Federal specifications, continuously variable test voltage control, and accurate test voltage metering directly across the electrodes. Full information may be obtained in Bulletin *4-60.1* from Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill. *Circle 223 on the card.*

There's a new meeting ground for electrical insulation facts!

WHERE: Cleveland, Ohio.

WHEN: September 3, 4, 5.

WHAT: the *first* National Conference on the Application of Electrical Insulation.

Co-sponsored by AIEE and NEMA, this 3-day *work session* is designed to aid the mutual exchange of ideas and technical information by maker and user alike.

It will lead to a better use of existing materials and to better direction in the development of new ones.

ACTIVITIES WILL INCLUDE:

- Technical sessions on all types of electrical insulation materials and their application in rotating machinery, controls and instrumentation, transformers, and electronic equipment.
- A commercial trade show for electrical insulation materials.
- Technical exhibits by manufacturers of electrical equipment.
- Open forum discussions with a panel of insulation experts.

Registrants will receive *pre-printed* copies of all technical papers to be presented during the Conference, as well as a record of questions and answers of the open forum discussions.

Make your plans *now* to attend.

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NATIONAL CONFERENCE ON APPLICATION OF ELECTRICAL INSULATION

29 West 39th Street, New York 18, N. Y.

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HIGH LEVEL
ENGINEERS
ON OUR TEAM
at
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in Southern California

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There are important positions available in these small, independent engineering groups at Bendix-Pacific for high level engineers from senior grade and up. Bendix-Pacific is particularly interested in strong, analytical engineers who have the calibre and capabilities to advance into systems engineering programs.

Please write W. C. Walker your qualifications or fill in the coupon and mail it today.

I am interested in this engineering field____
I am a graduate engineer with____degree.
I am not a graduate engineer but have ____ years experience.

Name_____
Address_____
City_____
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INDUSTRIAL NOTES

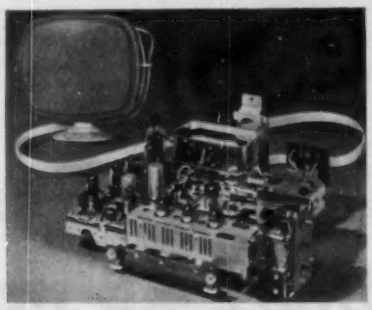
New Extrahigh-Voltage Power Line. An extrahigh-voltage power line has been placed in service between the Commonwealth Edison and American Electric Power Company systems. Customers of these two major utility systems, which together serve a population of nearly 12-million, thus will have added assurance of continued dependable electric service. The 345,000-volt line is one of the nation's largest for interchange of a bulk electricity supply between two power systems. The interconnection enables either system to call upon the other for help during an emergency and enables both to operate more economically with less generating reserve. Completion of the 90-mile tower line between Orland Park, Ill., and New Carlisle, Ind., came less than 2 years after the project was started. Commonwealth serves Chicago and northern Illinois. American Electric Power serves areas in Indiana, Michigan, Ohio, West Virginia, Virginia, Kentucky, and Tennessee. For further information contact American Electric Power Service Corp., 30 Church St., New York 8, N.Y.

Bendix Computer in Brussels. The Computer Division of Bendix Aviation Corporation is participating in the World's Fair at Brussels. The Commission in charge of the U.S. Pavilion has selected the Bendix G-15 digital computer for exhibition because it is one of the best examples of engineering "know-how" in bringing the benefits of automatic techniques to the average user as well as to the specialist. On-the-spot classes show Fair visitors how to code and operate the computer for individual problems. Manufactured by the Bendix Computer Division, 5630 Arbor Vitae St., Los Angeles, Calif., the G-15 is a middle-range, low-priced digital computer.

High-Voltage Test Equipment Purchases. In order to speed detection and location of incipient or existing faults in the maze of cables underlying the streets of the city, the Consolidated Edison Company of New York, Inc., has purchased over $100,000 worth of high-voltage test equipment from Beta Electric Division, Sorensen & Company, Inc., 333 E. 103rd St., New York 29, N.Y. Included in the purchase contract are a mobile cable test set and four combination leakage testers and fault reducers. The mobile cable test set is mounted in a truck, so that it can be sent anywhere in the city to test newly installed cables or to check on existing installations as part of the company's broad preventive maintenance program.

New Electronics Firm. Formation of Trolex Corporation, with production facilities and offices at 4322 Warren Ave., Hillside, Ill., has been announced. The company initially will manufacture a wafer switch for use in television, radio, and laboratory instruments, and will make control switching devices for electric ranges and air conditioning equipment.

Predicta. A separate screen television, developed by Philco Corporation, Philadelphia, Pa., brings a new horizon to home entertainment. Called the Predicta, this new kind of television features the revolutionary S-F (Special Form) picture tube and a completely redesigned chassis, each as a separate unit. Basically, a picture tube consists of three sections, the small neck at the back, a big funnel, and the face. The neck holds all the important components that make the picture. Since every part interacts with every other part, one cannot be changed without changing them all. Philco engineers redesigned the cathode and made it flat, with the result that it was shorter and also easier to heat. With a flat cathode, a little less length in



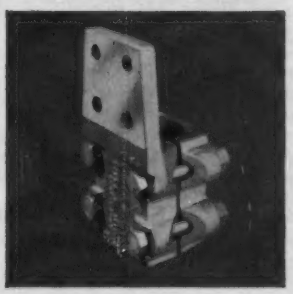
the neck was needed. New design of air space in the neck and a new treatment of certain connecting prongs allowed another fraction of an inch to be chopped off. The lens system was shortened. The circular coil which deflects the electrons in order to form a picture and center it on the screen is called the deflection yoke. An ingenious new shielding was built into this yoke to make it more compact and efficient. As a result the S-F picture is one of the shortest picture tubes yet developed.

Seattle Panelboard Assembly Facility. Federal Pacific Electric Company has established a panelboard assembly plant at 1415 Elliot Ave., in Seattle, Wash. The plant will be capable of delivering standard lighting and power panelboards to industrial, commercial, and utility customers on a 24- to 72-hour shipment basis. It will service the states of Washington, Oregon, Idaho, and Montana.

Wire-Wrap. A new machine that will automatically wire sections of electronic computers has been shipped by Gardner-Denver Company, Keller Tool Division, Grand Haven, Mich., to the Hughes Aircraft Co., Santa Monica, Calif. The $40,000 "Wire-Wrap" machine with electronic controls will be used for automatically wiring an airborne communications system known as "Lost Chord" for the Wright Air Development Center. The special unit that can be modified for other applications was produced by the Wire-Wrap Division of Gardner-Denver.

(Continued from page 46A)

EASY INSTALLATION. Bolt heads fall naturally into locking lugs on connector walls, making installation fast and sure with one wrench.



...assured with Delta-Star heavier-duty aluminum connectors

Delta-Star offers you a *complete line* of NEMA-standard aluminum conductor connectors. Their generous overall proportions and their contact surfaces which precisely match those of the conductors help assure maximum contact area and minimum contact resistance. Heavy cast-aluminum walls throughout make these Delta-Star Connectors rugged and immune to distortion under the most rigorous service.

Delta-Star Connectors are supplied in types and sizes to meet all requirements.

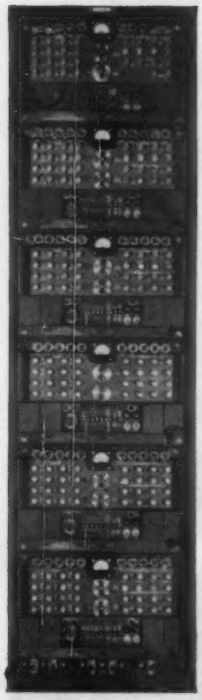
For complete information, write **Dept. 25C, Delta-Star Electric Division, H. K. Porter Company, Inc., 2437 Fulton Street, Chicago 12, Illinois. District offices in principal cities.**

H. K. PORTER COMPANY, INC.

DELTA-STAR ELECTRIC DIVISION

Connors Steel, Delta-Star Electric, Disston, Forge & Fittings, Leschen Wire Rope, Quaker Rubber, Refractories, Riverside-Alloy Metal, Vulcan-Kidd Steel, H. K. Porter Company (Canada) Ltd.

For more information circle 33 on reader service card.



MINIATURIZED CARRIER TELEPHONE SYSTEMS FOR RADIO AND 4-WIRE CABLE

FOUR OR 24 CHANNELS

Two miniaturized voice-multiplex systems providing four or 24 voice channels over radio or 4-wire cable are available. They have many advantages over earlier designs: high performance, small size, light weight, low cost, circuit simplicity, low power requirements, small number of tubes of a single type only, low operating cost, low maintenance and high reliability.

These systems provide a voice-channel flat within 1 db from 300 to 3500 cycles, for each 4 kc of bandwidth occupied. Each channel is equipped with hybrid, signalling, and dialling circuits for all the standard 2-wire and 4-wire loop options.

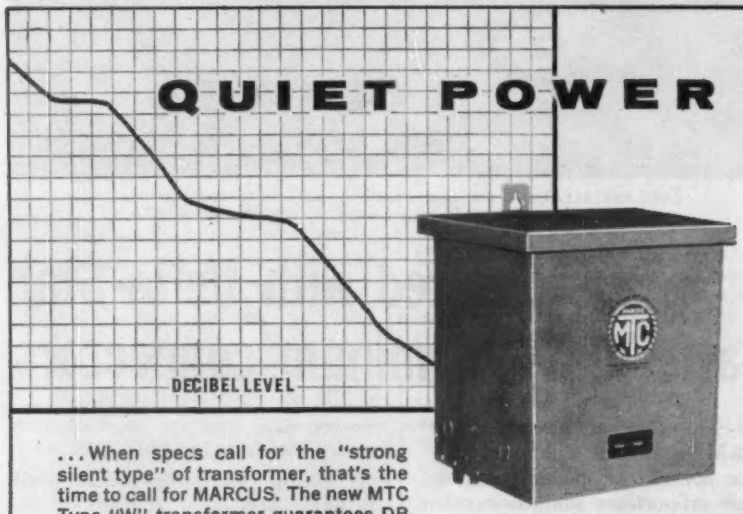
The basic unit provides an order-wire and 4 carrier-derived channels. These units can be stacked in groups of 2, 3, 4 or 5 by means of a group modem to provide 9, 14, 19 or 24 channels. Full flexibility is provided for dropping and inserting channel groups at repeater and terminal points. Moderate lengths of 4-wire cable or open-wire line may be inserted between the multiplex equipment and the radio terminals.

24-channel carrier-telephone terminal complete with hybrids, ringing and dialling circuits, and test facilities. Dimensions are 58" high, 16" wide and 8" deep. Power input 250 watts. Weight 326 lbs.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE UNiversity 6-6887 CABLES RADENPRO, MONTREAL

▲ Circle 34 on the card. ▼ Circle 35 on the card.

QUIET POWER



...When specs call for the "strong silent type" of transformer, that's the time to call for MARCUS. The new MTC Type "W" transformer guarantees DB LEVELS THAT ARE BELOW NEMA STANDARDS. So for those extra quiet installations, Specify MARCUS---- Proven quieter by independent laboratory test.

- LOWER SOUND LEVELS
- LOWER WEIGHTS
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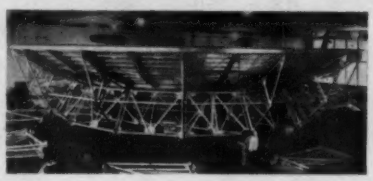
RAHWAY, NEW JERSEY
"Mark of Quality"
Representatives in Principal Cities

A COMPLETE LINE OF DRY-TYPE AND LIQUID-FILLED TRANSFORMERS FROM 1 THROUGH 5000 KVA.

Industrial Notes

(Continued from page 44A)

Sky-Chief Parabolic Antennas. The General Bronze Corporation, Garden City, L. I., N. Y., has announced the development of two new antenna designs which will be designated as their "Sky-Chief 60" and "Sky-Chief 90" paraboloid reflectors.



The 60-foot diameter antenna has one of the highest survival specifications. A survival point of 150-mph wind loading or 120-mph winds with 3 inches of ice, is claimed for this unit.

Gulton Subsidiary Enters Computer Field. A new Digital Devices Department that will apply semiconductor techniques to data acquisition and reduction in analog and digital systems has been established. The department has been assigned to the CG Electronics Corp., 15000 Central, East, Albuquerque, N.M., a wholly owned subsidiary of Gulton Industries, Inc.

Master Clock and Programmer. A master clock and program system for use in commercial, industrial, and public buildings has been introduced. The clock system includes a master clock, which usually is mounted in the office of a school principal or building engineer, and any number of secondary clocks located throughout the building. Also included is a programmer that breaks an electrical circuit at specified intervals to sound a bell, stop or start heating and air conditioning equipment, or turn lights on and off at certain times. A unique feature of the programmer is that its sequence can be changed by hand without specialized tools or a call to a professional serviceman. Detailed information on the master clock and programmer, which can be purchased as separate units, is available by writing Minneapolis-Honeywell Regulator Co., Commercial Division, 2747 Fourth Ave., South, Minneapolis, Minn.

Tracerlab. A service, designed to up-date company equipment now in use by incorporating the latest improvements and modifications is announced. Utilizing the advanced design and stability of their instrument line, the company is transforming instruments in current use into equivalents of the very latest in radiation research equipment. The service combines complete tracing and testing of circuitry and all mechanical components as well as complete overhaul and modernization of the physical appearance of the units. Further details of this unique program are available from Dept. KL, Tracerlab, Inc., 1601 Trapelo Rd., Waltham 54, Mass.

(Continued on page 50A)

No. 8 in a series

Right off the Wire

About half of this country has been converted to dial telephones and it is expected that within five or ten years, it will be possible to dial Europe or the Hawaiian Islands.

&

Two new developments in "fiber optics" (the use of glass or plastic fibers to transmit light around curves) are in the examination of the inside of the human body and in cryptography.

&

A new plastic reinforced with silica withstands high temperature better than steel.

&

A new technique in the use of radar antennas which involves sweeping the beam will give them a range of 3,000 miles without increasing their size.

&

Simplex researchers, D. W. Kitchin and O. S. Pratt, have developed techniques for taking photomicrograph movies of polyethylene insulation failures caused by excessively-high voltages.

&

A thermo-electric engine, based on the temperature differential between dissimilar metal plates, converts atomic energy directly into electricity with a thermal efficiency of twelve per cent.

&

A new machine uses the light from atoms of mercury to control the engraving of lines on diffraction gratings which must be less than a wave length of light apart. Accuracy is closer than one-millionth of an inch.

&

The strength of cast iron and resistance to high temperature are combined with good electrical resistance in a new ceramic.

By using a clock based on the vibration of an atom of cesium, it has been found that the length of our day has been increasing half a thousandth of a second per year.

&

A new television picture tube has a front of double glass with mineral oil between. This increases light transmission by reducing reflection.

&

A two-volt booster battery is made to supplement a regular automobile battery. It is used only in starting.

&

Simplex ANHYDREX XX insulation has greater resistance to deterioration at elevated operating temperatures than any natural rubber of GR-S heat resisting insulation.

&

A ramjet power plant for permanent earth satellites has been designed which would obtain its power from the re-combination of oxygen atoms that have been divided by cosmic radiation in the higher altitudes.

&

Further information on these news items and on Simplex cable is available from any Simplex office. Please be specific in your requests.

&

An electron tube the size of a shirt button is made of layers of titanium and ceramic. It makes the tube competitive in size with the transistor.

&

An instrument for detecting radiation is said to be so sensitive that it can detect a thousandth of a gram of chromium 51 dissolved in a river.

&

A patent has been issued for a television set that shows two programs superimposed on one screen. The images are separated by polarizing glasses and individual earphones reproduce the sound.

A treatment for metal bearings is claimed to make it possible to run them indefinitely without lubrication. It has also been tested on power press tools.

&

A three-dimensional cathode-ray tube gives a display with a depth of one mile.

&

A steel roller for a new paper mill is said to be the largest in the world. It is over twenty-six feet long and is forty-four inches in diameter.

Submarine cables for railroad use!

Submarine cable is required by the New Haven R.R. for the power and control of 24 movable spans at 14 railroad bridges. Old style steel armored cable suffered the ravages of salt corrosion, strong currents and constant flexing, all of which resulted in high maintenance. Replacements, as required, are made with new Simplex submarine cable, jacketed in fabric-reinforced neoprene — a product of Simplex research — a remedy for delayed service and high maintenance costs.

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Cambridge, Massachusetts and
Newington, New Hampshire

Simplex

Highest quality cables for: Mining
Power & Lighting • Construction
Transportation • Communications
Signalling

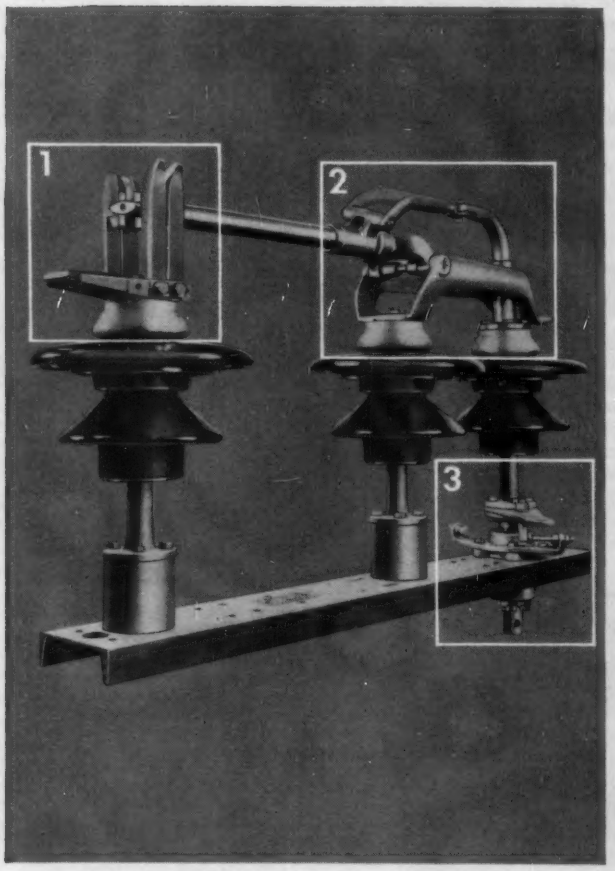
"The American manufacturers of transoceanic telephone cables"

For more information circle 36 on reader service card.

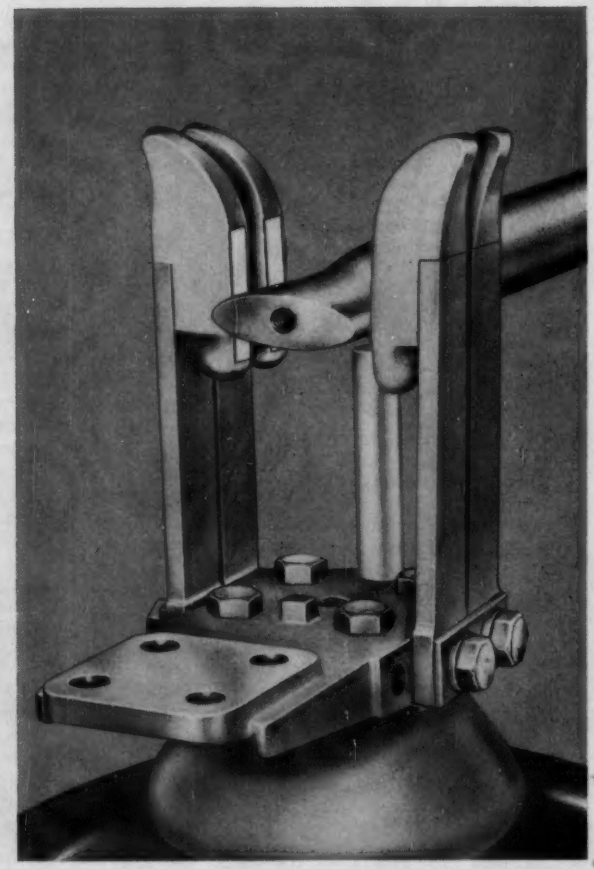
R&IE OUTDOOR DISCONNECTING SWITCHES

EASY TEST FOR

Look for these design features . . . they explain why



Look for rounded contours on all parts and liberal spacing between parts having relative motion. R&IE switches, designed this way, can be actuated under severe icing conditions with surprising ease. Other switches, with complicated or closely packed mechanisms, are generally handicapped by relatively thin ice coatings, locked by heavier ones.

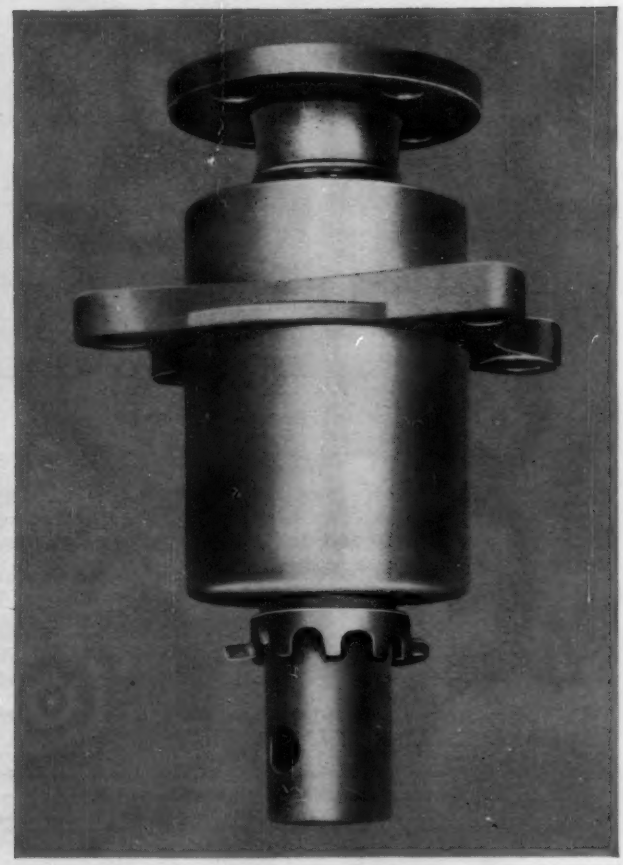


1 Look for heavy copper jaw fingers—silver-to-copper contacts. Thus constructed, R&IE switches show no evidence of overheating when tested well above their short-time current ratings. R&IE avoids the use of thin stamped jaws, which lack thermal capacity, often burn or erode under overload or fault currents . . . requiring more frequent maintenance.

Compare R&IE switches, point by point, with others. Discover the extra assurances of better performance, which you get at no extra cost. Available in ratings from 7.5 to 345 kv and from 400 to 6000 amp. For complete information, ask your nearby I-T-E sales office for a copy of Bulletin 1342-A. Or write R&IE Equipment Division, Greensburg, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ont.

BETTER SWITCH DESIGN

you can expect better performance from R&IE switches

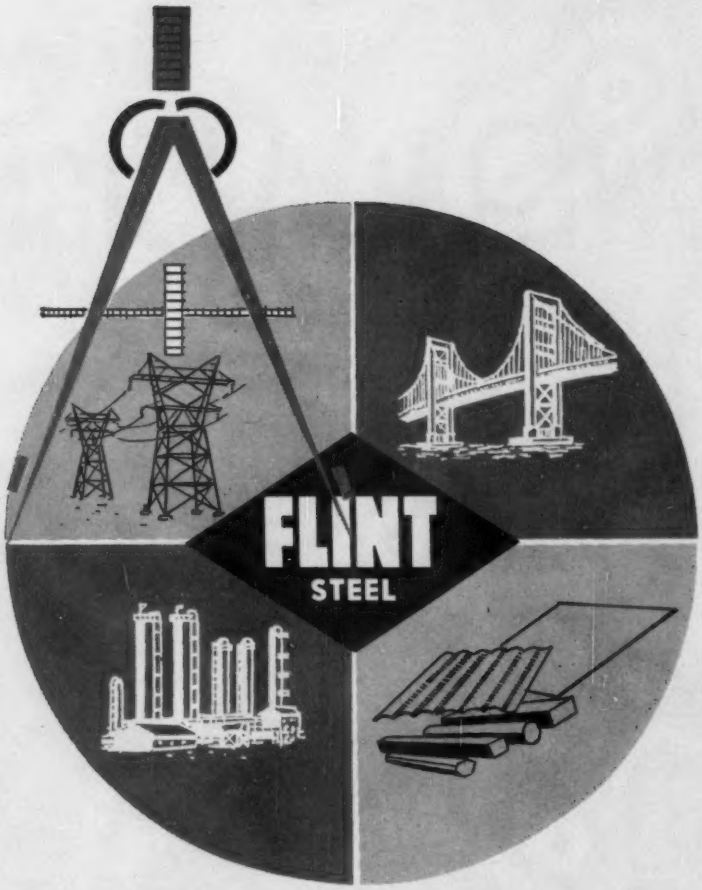


2 Look for sealed hinge-end contacts. R&IE switches have weather-sealed contacts at the hinge end for continuous low-resistance current transfer. Exposed hinge-end contacts are vulnerable to ice locking and, when corroded, lower short circuit capacity. Look also for only nonferrous exposed live switch parts . . . an R&IE feature which assures long switch life.

3 Look for a sealed, greaseless switch bearing. This part transmits turning force from the operating crank to the switch actuating mechanism. The R&IE switch bearing, sealed against moisture and foreign matter, is not affected by low temperature and requires no lubrication. Unsealed bearings are subject to fouling by ice and dirt, making switch actuation difficult or impossible.

I-T-E CIRCUIT BREAKER COMPANY
R & I E EQUIPMENT DIVISION • GREENSBURG, PA.

For more information circle 37 on reader service card.



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TULSA . . . MEMPHIS

Structural steel can now be delivered promptly and when required.

For more information circle 38 on reader service card.

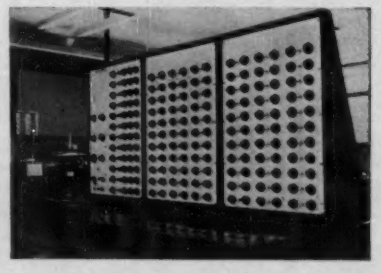
Industrial Notes

(Continued from page 46A)

New Radio Beam System. Telegraph facilities for the midwest area were greatly increased by The Western Union Telegraph Company, 60 Hudson St., New York 13, N.Y., when a 557-mile microwave radio beam system was placed in operation between Pittsburgh, Pa., Cincinnati, Ohio, and Chicago, Ill. The new beam system will provide additional channels for use in telegraph service, and will enable the telegraph company to keep pace with the rapid growth of its private wire and facsimile systems leased to industry, the armed services, and government.

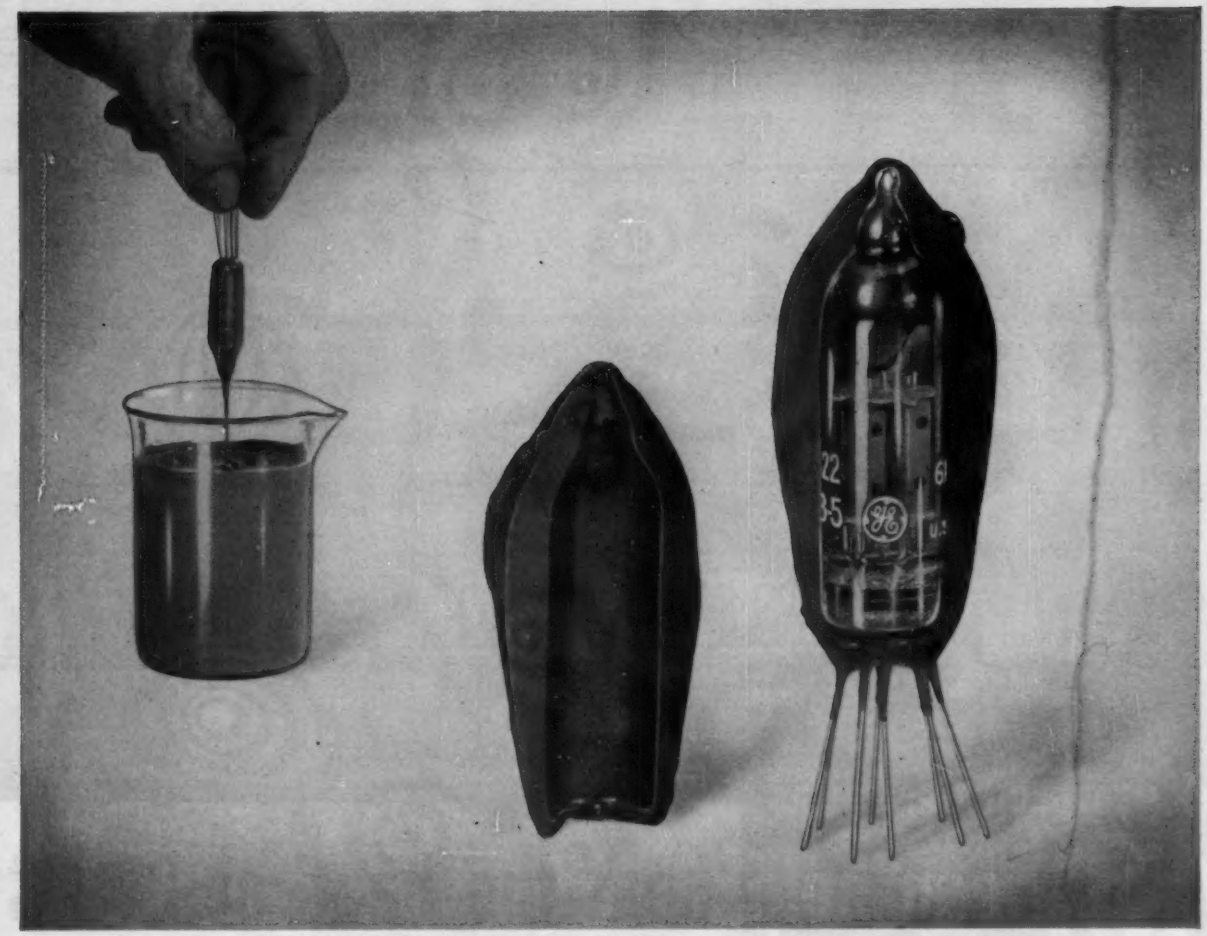
K-Slab. A new type of cast aluminum bar developed by Kaiser Aluminum & Chemical Corporation, Kaiser Bldg., 1924 Broadway, Oakland 12, Calif., is being used as bus bar at the new reduction plant in Ravenswood, W. Va. The company installed 3 million pounds of the new aluminum bar, called K-Slab, for cathode and anode bus bar on the first two potlines at the Ravenswood plant, with substantial savings resulting. In addition, the company has also installed 1.5 million pounds of K-Slab as potline conductor on the new ninth potline at Kaiser Aluminum's Chalmette, La., reduction plant.

Scientific Lighting Design. Much of the guesswork has been taken out of lighting design, thanks to the lighting engineers at Smoot-Holman Company, 321 N. Eucalyptus Ave., Inglewood 3, Calif., who have built a luminous analogue computer that makes lighting calculation a matter of exact science. This new machine determines exactly how light is distributed



within a room by setting up electrically inside the computer the same lighting conditions as those in the room. By doing this the computer is able to make calculations that determine the brightnesses and amount of light within the room.

Pocket-Size Police Aide. A pocket-size two-way radio system developed by the Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N.Y., soon will be aiding New York City policemen in their fight against crime in the city's sprawling 34,000-acre park system. The unit, which can be carried in the pocket or clipped to the belt, is said to have a range of up to 2 miles in communication with mobile units and even longer with fixed stations. It will enable the wearer to summon help from any spot on his beat. Return instructions will come from a transmitter being erected in Central Park at 79th Street.



G-E RTV is an easily applied potting and encapsulating material. Tough, heat-resistant, resilient, it does not shrink or form voids during cure.

New RTV silicone rubber from G.E.

CURES WITHOUT HEAT • LOW VISCOSITY • SOLVENT-FREE • NO VOIDS OR SHRINKAGE

CURES WITHOUT HEAT G.E.'s RTV (room temperature vulcanizing) silicone rubber cures at room temperature in any time you select up to 48 hours. It comes in a wider viscosity range than any similar compound—from 250 poises (pourable) to 15,000 poises (spreadable). Easily applied by pouring, dipping, spreading or with a pressure gun.

WON'T SHRINK, VOID-FREE RTV compounds are 100% solids (no solvents). They cure without shrinkage; form no voids; provide resilient, shock-absorbent protection against physical damage or moist and corrosive atmospheres. Tensile and tear strength exceed those of previously available materials and are retained after prolonged heat aging.

RESISTS HEAT ABOVE 300°C General Electric RTV silicone rubber keeps its high dielectric strength at temperatures above 300°C. It has the well-known properties of silicone rubber, such as ability to withstand moisture, weathering, ozone, corona, oxidation and exposure to fuels and solvents.

IDEAL FOR POTTING AND ENCAPSULATING General Electric RTV compounds flow easily into and around complex shapes. They are ideal for potting and encapsulating. Other uses include caulking and sealing in hard-to-reach places, performing "on-the-spot" rubber repairs, model making and molding in low-cost plastic tooling.

For complete application data, check Reader Service Card. If you'd like a sample for evaluation, drop us a note telling us about your proposed application.

OPERATION up turn GENERAL ELECTRIC

GENERAL ELECTRIC

Silicone Products Dept. **Waterford, N. Y.**

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ON SEMICONDUCTOR FRONTIERS

YOU can help 'beat the heat' at 200°C

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PHYSICAL CHEMISTS

SOLID STATE PHYSICISTS

ELECTRONIC ENGINEERS at TI are beating the semiconductor heat barrier with devices that will operate at 200 degrees centigrade and higher – twice the boiling point of water! Working closely with other scientists on the TI team, they continually explore new fields in electronics. Under the hot glare of infrared light which simulates extreme operating conditions, the engineer shown above is testing the newest TI silicon power transistor operating in conjunction with the totally new *Sensistor* temperature-sensing silicon resistor.

On this frontier, there is plenty of room for electronic engineers, physical chemists, solid state physicists, and others to build America's electronic future. If *you* are interested in joining other leading engineers and scientists at the industry's most modern research, development and production facilities – write or call for more information on 28-year-old Texas Instruments, recognized leader of the semiconductor industry. You will discover up-to-date supplemental benefits – profit sharing, insurance, retirement programs, and company-sponsored educational assistance.

Semiconductors and Other Components – Transistors, diodes, rectifiers, capacitors, resistors, transistor circuit applications, test equipment, mechanization. Write Harry Laur.

Electronic and Electromechanical Apparatus – Radar, sonar, infrared, optics, navigation, magnetics, telemetering, communications, computers, transformers. Write R. E. Houston.

Research and Manufacturing – PhD level for research, development and applications: solid state device technology, ferromagnetics, infrared, microwave, magnetics, digital computers, radar, sonar, telemetering, etc. Engineers for production, planning, purchasing, cost analysis, etc. Write A. E. Prescott.

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New MS Miniature Plug

WITH SOLDERLESS SNAP-IN CONTACTS

Cuts Wiring Assembly Time as much as 80%

CANNON KM SERIES
FIRST TO MEET MIL-C-25955 (USAF) SPECIFICATIONS

THE PROBLEM—To design a miniature environmental-resistant connector, suitable for use on present and future aircraft, missiles and equipment, in accordance with military requirements. Dependability with simplicity to facilitate assembly, installation and field service were vitally important.

THE SOLUTION—Crimp-type solderless contacts, with wire insulation support, are used in the new KM. They can be easily snapped into place, or removed as necessary. Individual contacts can be serviced one at a time, without removing others. A specially designed moisture-sealing grommet replaces potting. Closed entry, machined socket contacts are probe-proof. All materials are of finest obtainable quality. Shells and related parts are of aluminum alloy, cadmium plated. Contacts are plated with gold over a heavy silver undercoat.

These features combine to provide a plug of optimum reliability that can be assembled and installed with utmost speed and be easily serviced in the field.

The new KM mates with the Cannon KO Plug Series, and is available in a wide variety of shell sizes, styles and insert layouts. Hermetically sealed receptacles also available. *For complete information write for Catalog KM-1.*

Come to Cannon for all plug needs—27,000 kinds to choose from. If we do not have what you want we'll make it for you. The largest facilities in the world for plug research, development and manufacturing are at your service. Write us today about your problem. Refer to Dept. 117

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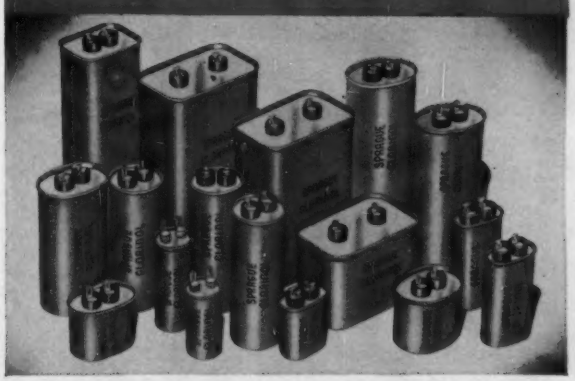
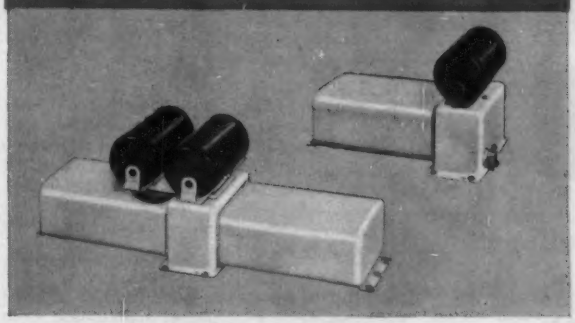


CLORINOL Capacitors are designed to save both space and weight and to help reduce costs in many typical a-c applications. Their drawn seamless steel cases make them extra sturdy, extra compact. They're made to resist corrosion . . . to take hard knocks and bangs . . . to withstand gruelling duty cycles. Double-rolled edges of the cover closure eliminate "pop-outs". The unique welded terminal assembly forms a dependable leakproof seal. The impregnant is a non-flammable synthetic liquid of high dielectric strength. Dual-blade universal terminals fit both popular types of female quick-connectors. Available in all the popular ratings and in three case styles—oval, rectangular, and cylindrical. Request Engineering Bulletins No. 4500 (general data), 4510 (oval), 4520 (rectangular), and 4530 (cylindrical).

KOOL-PAK* Capacitor Assemblies



KOOL-PAK Capacitor Assemblies provide complete motor-start and motor-run capacitance in one, easily installed unit that's perfectly matched to your requirements. The capacitors in each assembly are completely exposed for cooler operation. The internal heat is dissipated quickly by conduction and convection. These cooler-running capacitors last from two to three times longer than those that are stuffed into conventional box packages. KOOL-PAK assemblies cost you less because there's no outer box, no special leads or terminals to buy for interconnecting multiple capacitors. All units are finished to pass Article 207 of Underwriter Laboratories', Inc. requirements for air conditioners. Request Engineering Bulletin No. 4900A.

*Trademark

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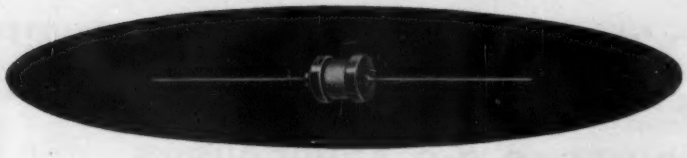
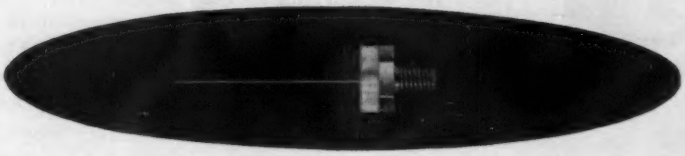
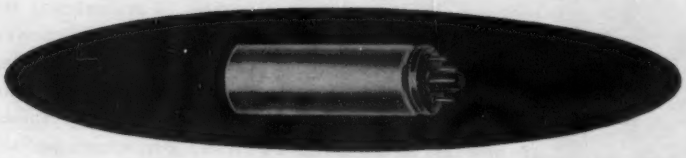


. . . or 10 amps



. . . or 200 amps

. . . or tube replacements



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TRADE LITERATURE

Altitude Pressure Table. Engineers working in the fields of high altitude and low pressure will find useful a wallet-size millimeters of mercury table giving the equivalent pressures for the range of altitudes from sea level to 2 million feet. Copies of the Altitude Pressure Table, which is based on the Air Research Development Center Model Atmosphere of 1956, will be sent free on request to the Vacuum Equipment Division, F. J. Stokes Corporation, 5500 Tabor Rd., Philadelphia 20, Pa.

Aerosciences Booklet. Applied research in space technology, plasma dynamics, and hypersonics is described in a free 16-page booklet, available by writing to Missile and Ordnance Systems Department, Room 5A, General Electric Company, 3198 Chestnut St., Philadelphia 4, Pa.

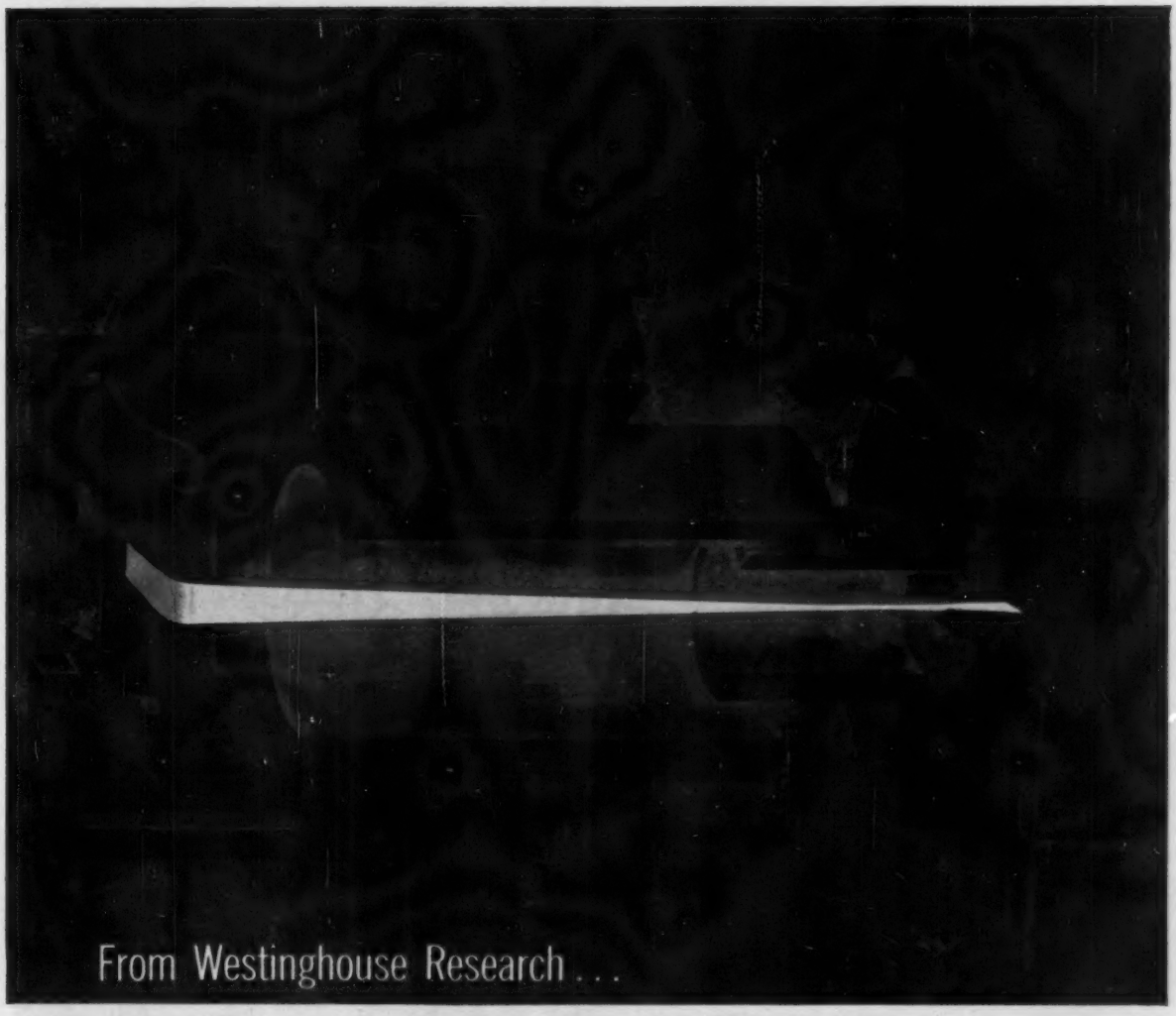
Bulletin on Photoelectric Cells. The complete line of self-generating photoelectric cells manufactured by Vickers Incorporated, Electric Products Division, is described in a new 12-page bulletin recently published by the company. Encompassing a wide range of shapes and sizes, Vickers photoelectric cells are the self-generating barrier layer type, consisting of a metal base with coating of selenium and other metals. A copy of Bulletin *EPD 3216-1* is available from Vickers Incorporated, Electric Products Division, 1815 Locust St., St. Louis 3, Mo.

Ultrasonic Delay Lines Booklet. A 4-page data bulletin outlining performance characteristics and design considerations for ultrasonic delay lines is available. Subjects covered are: delay medium material, transducers, bonding medium, casing, and packaging. Three pages are devoted to the performance characteristics of five different ultrasonic delay lines. Request Bulletin No. *510* from the Bliley Electric Company, Union Station Bldg., Erie, Pa.

Electrical Connector Soldering Booklet. A 10-page report that gives a step-by-step procedure for the soldering of miniature electrical connectors is available. Entitled "Electrical Connector Soldering Techniques," copies can be obtained by contacting The Deutsch Company, 7000 Avalon Blvd., Los Angeles 3, Calif.

Tape-Wound Core Bulletin. The development of a wide-line of tape-wound cores of Supermendur has been announced by the Arnold Engineering Company, P.O. Box G, Marengo, Ill. In the field of circuit miniaturization and simplification the unique characteristics of this new rectangular-loop material in the range of induction from 16 to 22 kilogausses permit important weight and size reduction of toroidal transformers and magnetic amplifiers. Bulletin *TC-113A* contains essential information on Supermendur tape-wound cores and covers the physical and magnetic properties of the cores as well as the sizes available.

(Continued on page 64A)



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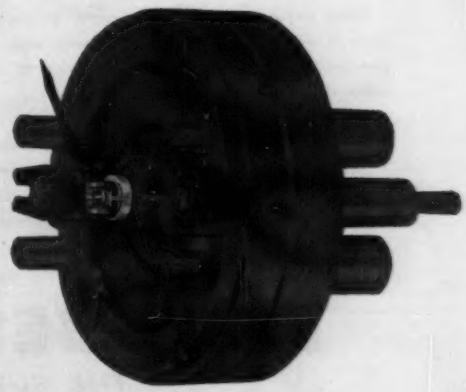

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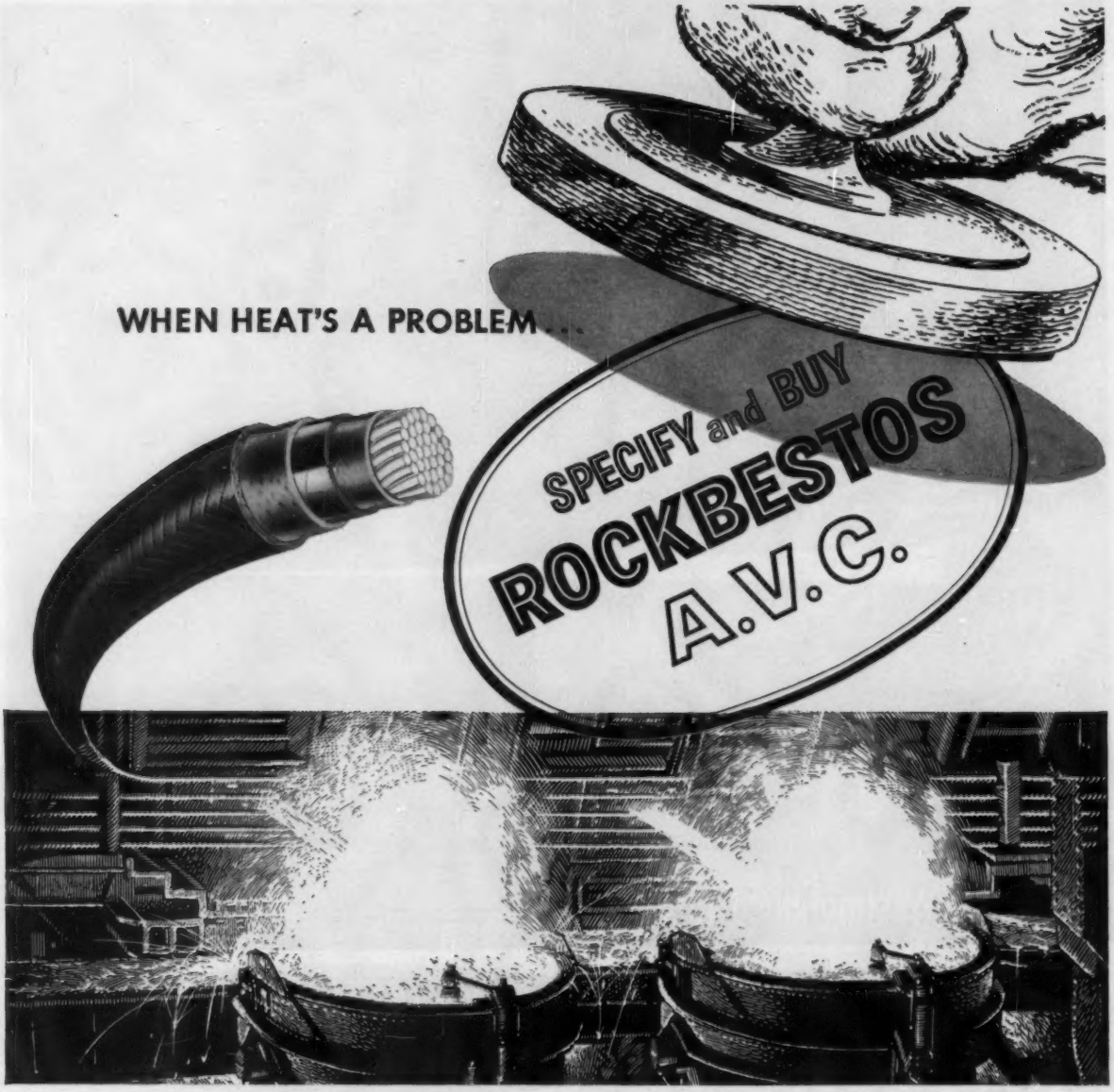

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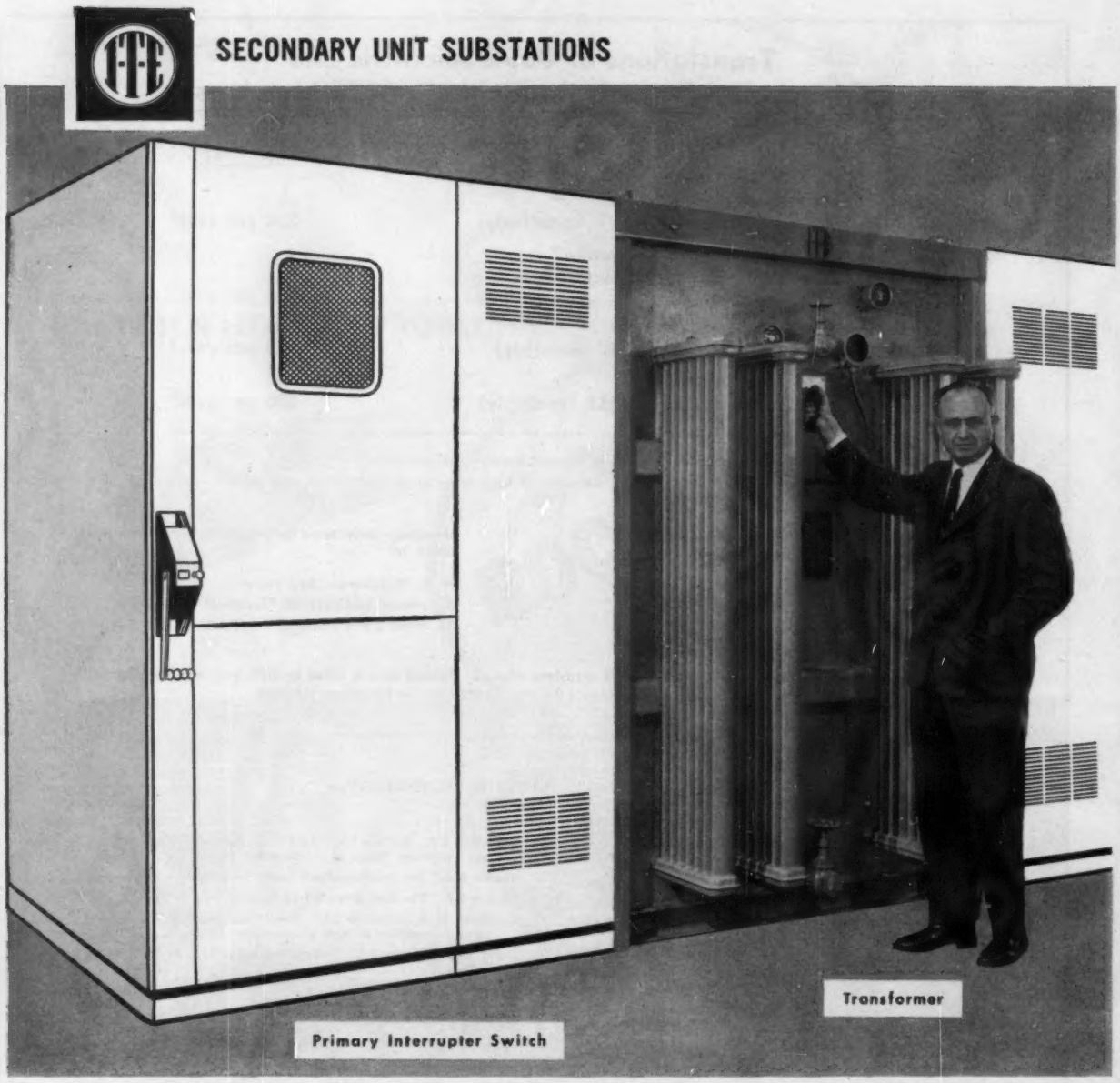

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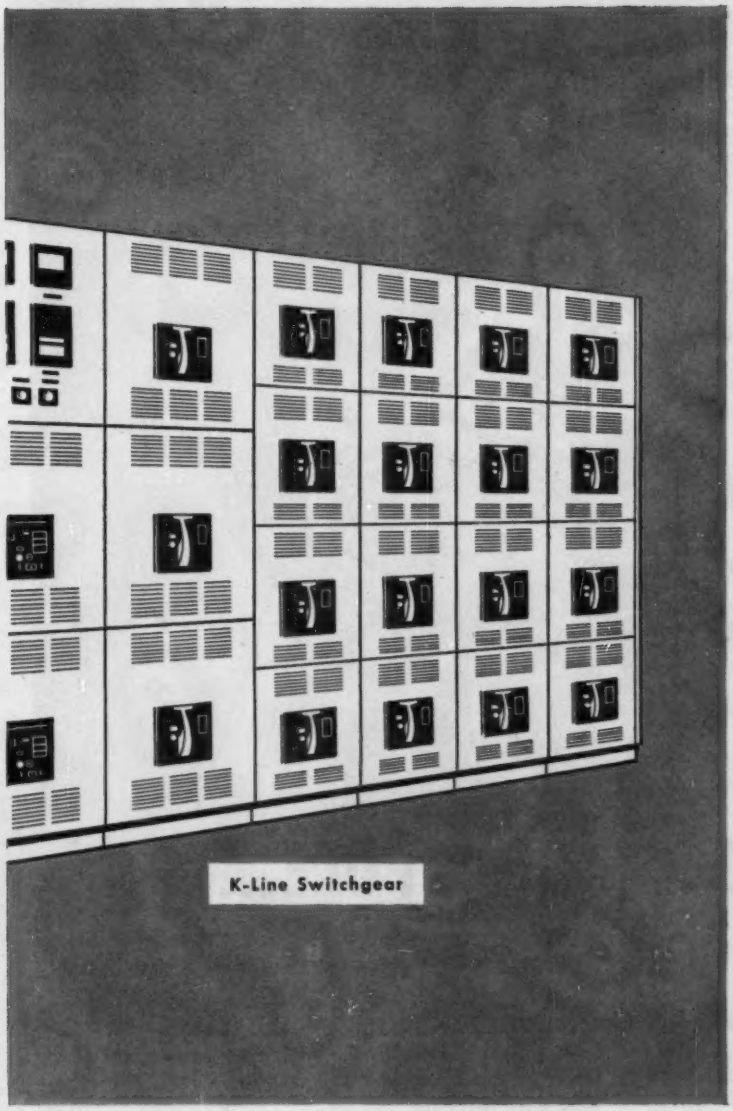

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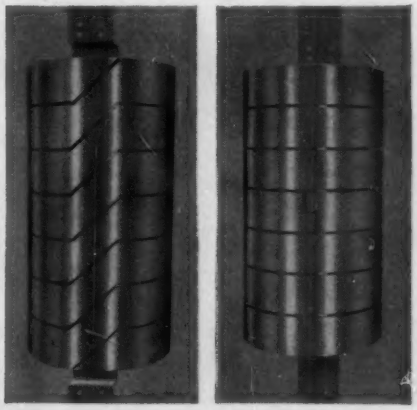

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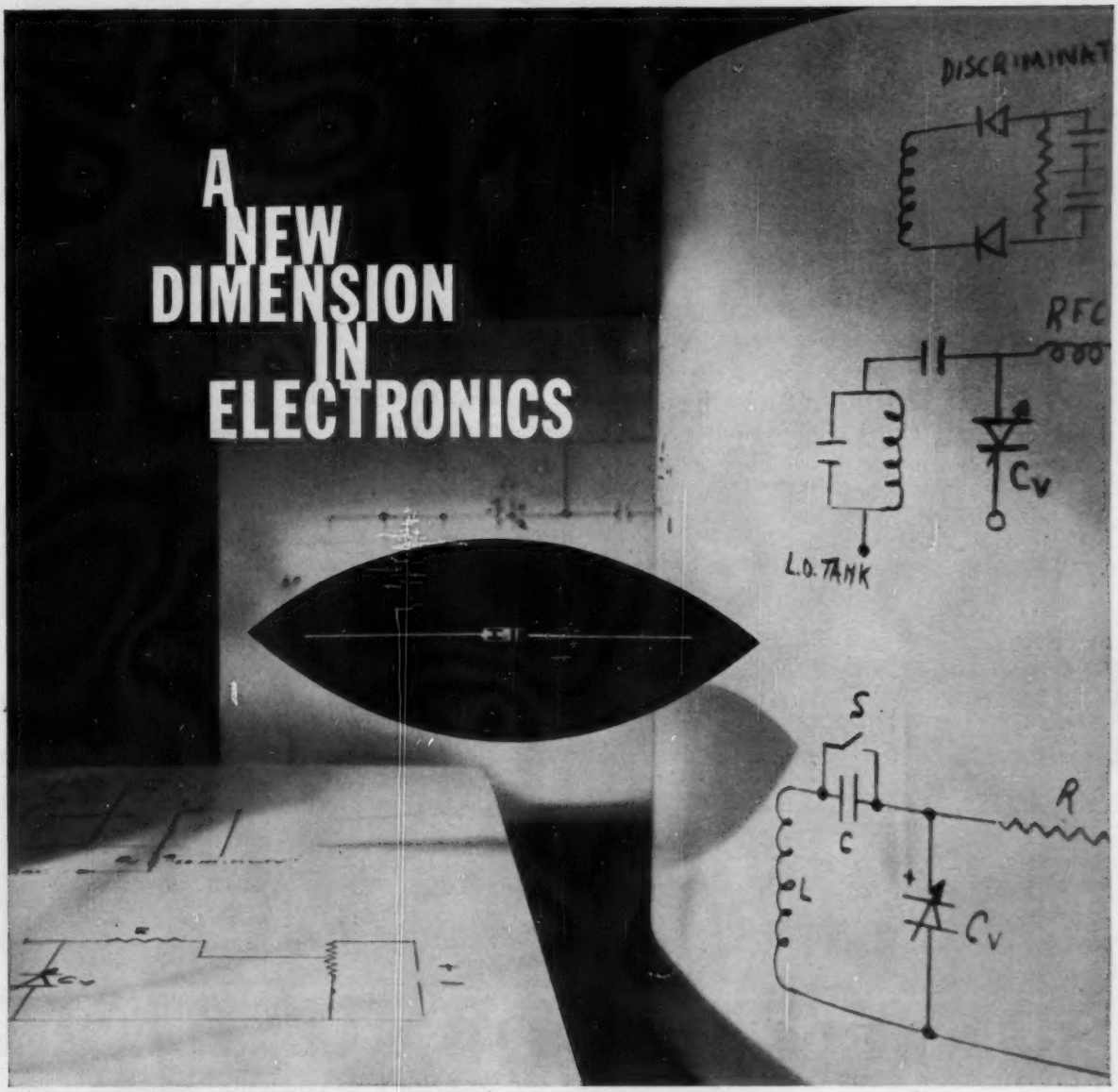

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Trade Literature

(Continued from page 56A)

Colloidal Graphite. A booklet, "The ABC's of Colloidal Dispersions," has been issued by Acheson Colloids Company, Port Huron, Mich., Division of Acheson Industries, Inc., manufacturers of the dag (registered trademark) family of dispersions designed for a wide variety of industrial uses. The 12-page booklet provides the answers to many of the questions frequently asked about colloids with story, drawings, and pictures. The back cover lists technical bulletins available from the company on the uses of colloidal graphite and other materials.

Simplified Computer Method Bulletin. A 4-page bulletin describing the unusual features of a new programming method is available from Bendix Computer Division, 5630 Arbor Vitae St., Los Angeles, Calif. This system, known as *Intercom 1,000*, has been designed for use with the Bendix *G-15* general purpose digital computer and is a major simplification in the process of writing instructions to a computer. The system can be learned in a short time, with no previous computer experience.

Asbestolux Brochure. Lightweight fireproof insulation board, Asbestolux, is the subject of a new 12-page brochure recently published. The booklet pictures and describes a cross-section of uses for factories, homes, offices, schools and farms. It includes illustrations of dozens of existing installations in a variety of buildings. The booklet, which also explains the properties and easy workability of Asbestolux may be obtained without obligation through North American Asbestos Corporation, 3210 Board of Trade Building, Chicago 4, Ill.

Microphone Catalog. A 16-page catalog has just been issued by American Microphone Manufacturing Company, a Division of GC-Textron, Inc. The catalog describes in detail the company's full product line. Included are microphones for tape recording, broadcast, public address, and general purposes, as well as handsets, phono cartridges and arms, mobile equipment, and accessories. The handsomely designed, 2-color Catalog *58* is available free from American Microphone distributors, or by writing direct to American Microphone Manufacturing Company, 412 South Wyman St., Rockford, Ill.

Distribution and Control Equipment Booklet. Bulletin *S*, a 12-page 2-color booklet briefly describing its building and industrial lines of electrical distribution and control equipment, has been issued by Federal Pacific Electric Company, 50 Paris St., Newark 1, N. J. Copies of the booklet can be obtained by writing to the company.

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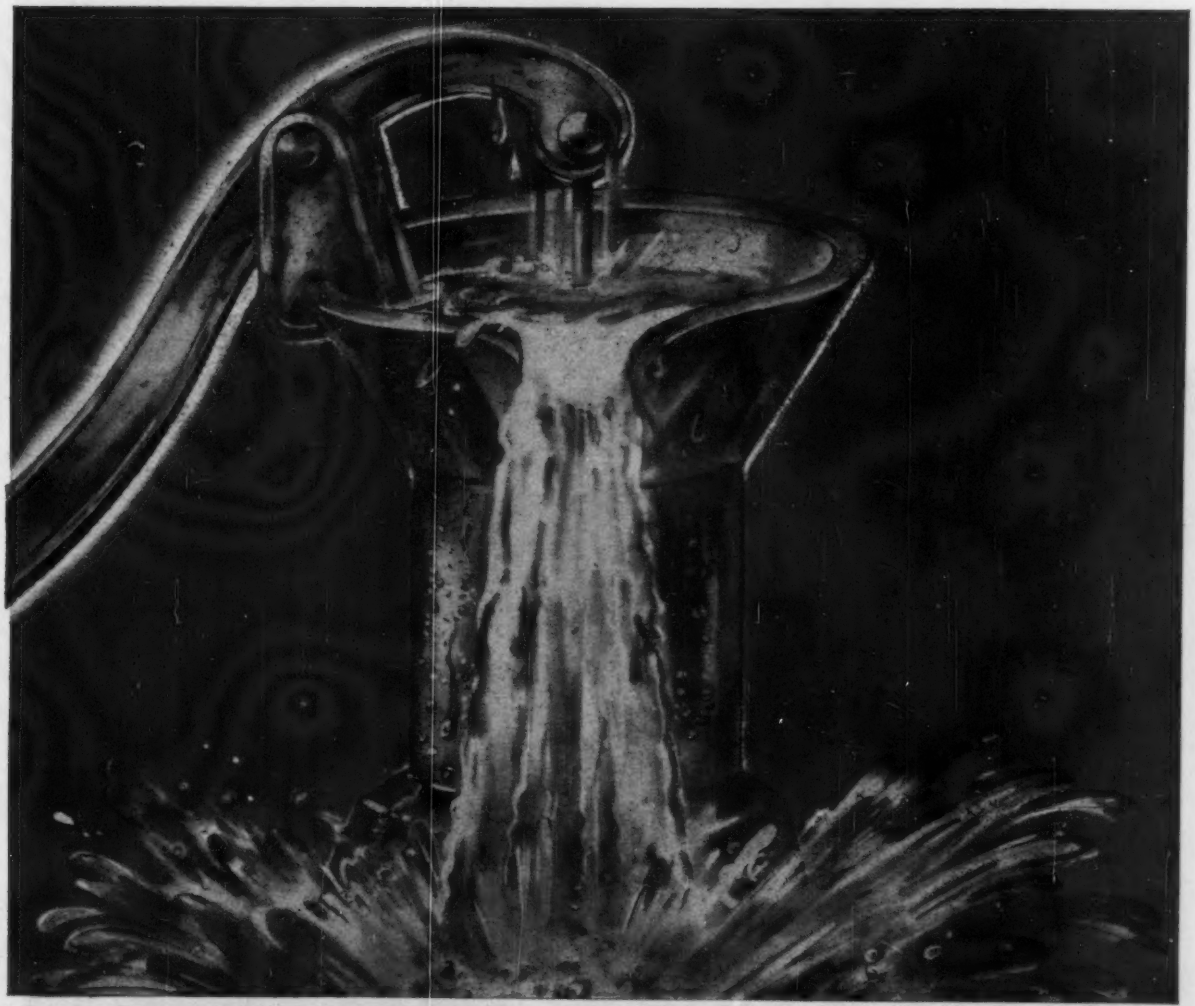

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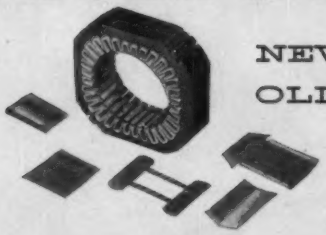

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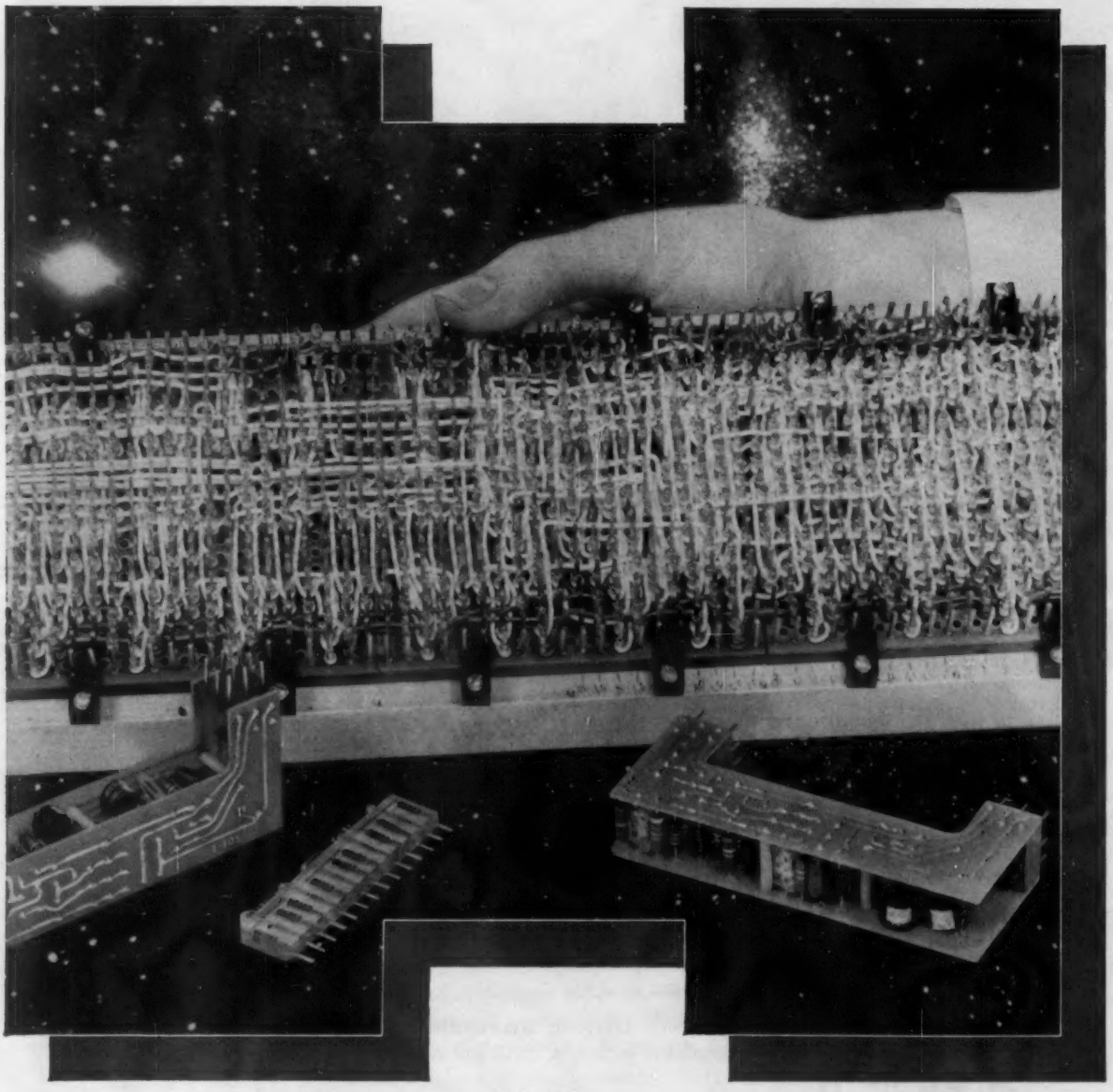

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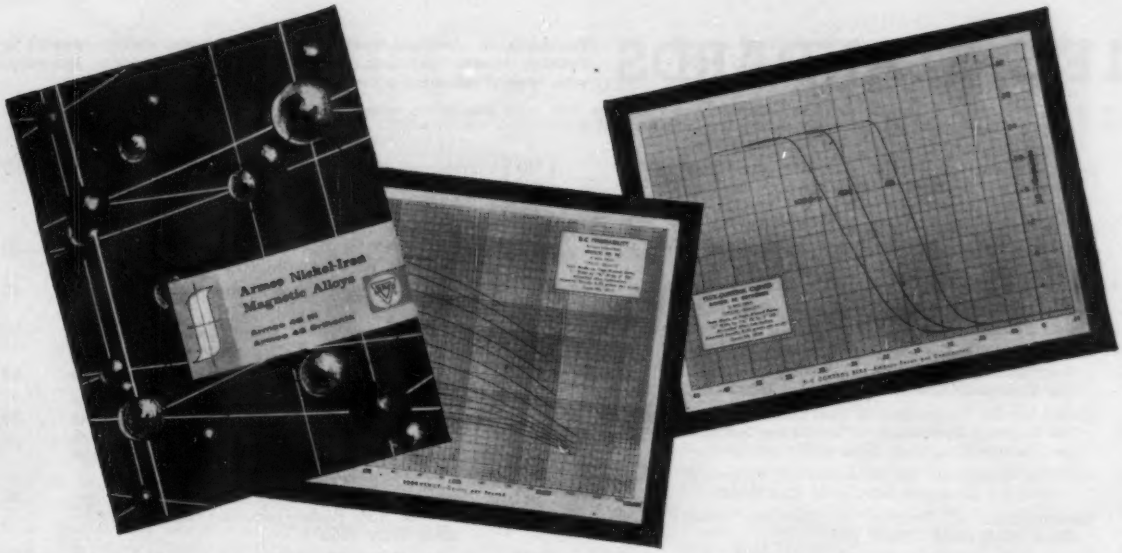

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Standards on electrical machinery and apparatus chiefly devoted to defining terms, conditions, and limits which characterize behavior, with special reference acceptance tests.

A discount of 50% is allowed to Institute members except as noted. College and bona fide public reference libraries are allowed (except in special cases with † below) a discount of 50% for nonmember prices; dealers and subscription agencies 20%.

1	General Principles Upon Which Temperature Limits are Based in the Rating of Electric Equipment (June 1957)	$0.80
1A	General Principles for Rating of Electric Apparatus for Short-Time Intermittent or Varying Duty (Sept. 1941) (A proposed supplement to No. 1)	—
1B	Guiding Principles for Specification of Service Conditions in Electrical Standards (May 1944)	.40
1D	Guide for the Preparation of Test Procedures for the Thermal Evaluation of Electrical Insulating Materials (June 1957)	—
1E	Guide for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment (June 1957)	—
3	Guiding Principles for Selection of Reference Values for Electrical Standards (Oct. 1943)	.60
*4	Measurement of Voltage in Dielectric Tests (Sept. 1953) (ASA C68.1)	.80
*11	Rotating Electric Machinery Forming a Part of the Power Equipment on Electrically-Propelled Railway Cars, Locomotives, and Coaches (Trolley and Prime Mover) (Oct. 1957) (ASA C35.1)	.60
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*17†	Mathematical Symbols (Jan. 1928) (ASA Z10f)	.40
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54	Standard, Test Code, and Recommended Practice for Induction and Dielectric Heating Equipment (Sept. 1955)	.80
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56	Guide for Insulation Maintenance for Large A-C Rotating Machinery (Feb. 1958)	.60
62	Guide for Making Dielectric Measurements in the Field (Apr. 1958)	1.00
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425	Test Code for Transistors (Aug. 1957)	1.20
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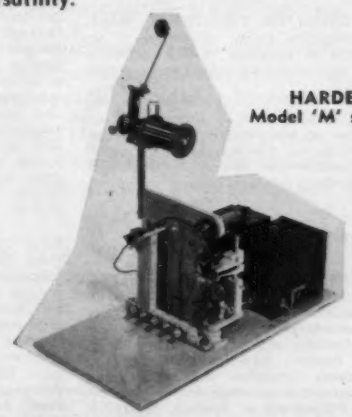

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ENGINEERS. (a) Application Engineer, 28-40, graduate electrical, with electrical apparatus experience either in engineering or sales; experience in writing technical letters. Will handle correspondence from sales engineers and customers on inquiries for technical and product information; make occasional product presentations; service equipment in territories not covered by sales engineers. Salary, $7800-$10,000 a year. Occasional travel. (b) Sales Engineers, graduate electrical, to handle the sale of electrical apparatus such as fuse cutouts, lightning arresters, switches, capacitors, etc. Must have proven and successful sales record, and some utility experience. Salary, $7800-$12,000 a year depending upon qualifications. Territories; New York, N. Y., Chicago, Illinois, Atlanta, Georgia, and Cleveland, Ohio. W6180.

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ASSISTANT OR ASSOCIATE PROFESSOR for Department of Electrical Engineering M.S. degree minimum, with teaching experience desired. Major interests in circuits, computers or servos. Will teach and develop courses for undergraduate students. Salary open. Location, Midwest. W6196.

SENIOR RESEARCH ENGINEERS, B.S.E.E. but advanced degrees preferred; ten years' experience in handling projects from inception through design and development. Heavy background in R & D, proposal writing and studies. Ability to carry project responsibility in one or more of the following fields: Radar, countermeasures and ferret systems; microwave systems and components; antennas and propagation with emphasis on UHF, VHF and microwaves; digital and analog computers, data processing, television systems and high definition displays; pulse and video circuits. Salary, $10,000-$15,000 a year. Location, New York suburban area. W6199.

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HEAD, of School of Electrical Engineer, Ph.D. degree, late thirties or early forties; teaching, industrial and research experience; publications in recognized journals. Eleven months duty, one month vacation; limited consulting activities; salary range, $11,000-$13,000 a year depending upon qualifications. Available July 1959. Location, Southwest. W6217.

ELECTRICAL ENGINEER with approximately ten years' experience in power, motors, power distribution and instrumentation; not over 40; for a consulting engineering firm. Location, Midwest. W6218.

ELECTRONIC ENGINEERS, 25-40, graduate electrical, with a minimum of three years' diversified experience in the manufacture of precision electromechanical products. Work in circuit and product design such as subminiature motors, electronic controls, relay switching devices perferred. Will design basic electronic equipment such as power supplies, dividers, multi-vibrator circuits, filter networks and RC circuits. Must be U.S. citizen. Salary, $6500-$8300 a year; good fringe benefits. Location, New York, N. Y. W6222.

ELECTRICAL SALES ENGINEER, 25-35, for leading manufacturer of D.C. generators and rectifiers expanding its operations; B.S. in electrical engineering or equivalent with five years' experience in electrical engineering or electrical sales. Work will involve assisting other salesmen, quotations, special projects and direct selling. Some traveling involved. Salary open. Company will negotiate placement fee. Location, East. W6253.

PROJECT ENGINEER, B.S. in Electrical Engineering or B.S. in radio engineering, with three to five years' experience on specialty motor design and development. Experience on miniature gear motors, servos, synchronous motors, etc. Will design and develop miniature 400 cycle gear motors, servo motors, hysteresis synchronous motors, small alternators, induction motors, etc. Location, New Hampshire. W6257.

ELECTRICAL ENGINEERS, B.S. or M.E. in electrical engineering, with at least two years' experience in electronic circuit and systems design, for electronic control circuit and systems design. Location, New York State. W6259(b).

ENGINEERS. (a) Senior Engineer, M.S. or B.S. in E.E., with additional experience, three to five years' experience in design, development, engineering, fabrication, testing of electronic devices or systems. Will handle a major portion of large project or small project in its entirety in wide range R.F. circuitry. Salary, $8000-$10,000 a year. (b) Engineering Aide, responsible for solving less complex problems in a development project involving research, design of a device or system under a project engineer. Salary, $6500-$7500 a year. (c) Product Engineer, graduate E.E., two years' experience in development of deliverable military equipment built to MIL specifications. Will be responsible for the design and methodizing production phases of projects, design of jigs and fixtures, methodizing repetitive tests techniques, etc. Salary, $6500-$8000 a year. Location, Pennsylvania. W6262.

ASSISTANT PLANT ENGINEER, electrical graduate, with industrial electronic experience including high frequency induction equipment in process industries. Salary, $7000-$8000 a year. Location, central Pennsylvania. W6289.

ENGINEER, university graduate, with at least five years' experience in the operation of steam electric generating station for responsible position. Preference will be given to Spanish speaking applicant. Salary dependent upon qualifications. Location, South America. F6293.

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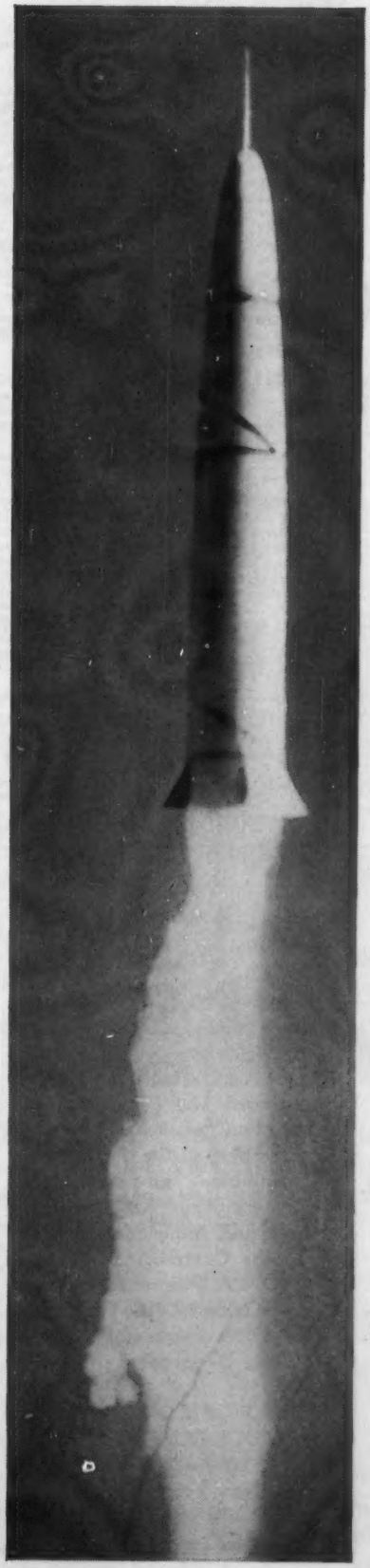
ELECTRICAL GRADUATE with a minimum of eight years' experience in the design of power and light, preferably for airforce military installations. Salary, $12,000 a year. Location, Middle East. F6272((a).

(Continued on page 74A)



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(Continued from page 72A)

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DESIGNER CHIEF, electrical, preferably registered in California, under 40, with minimum of ten years' experience in petro chemical refinery work (tower and controls-remote operating supervisory and instrumentation). Will be first in the electrical department and should be a working leader with ability to do these things: Supervise, direct and instruct others, work with associates and deal with chemists; have capacity to develop into associate within the firm. Salary, about $10,800 a year. Location, Los Angeles. S3618.

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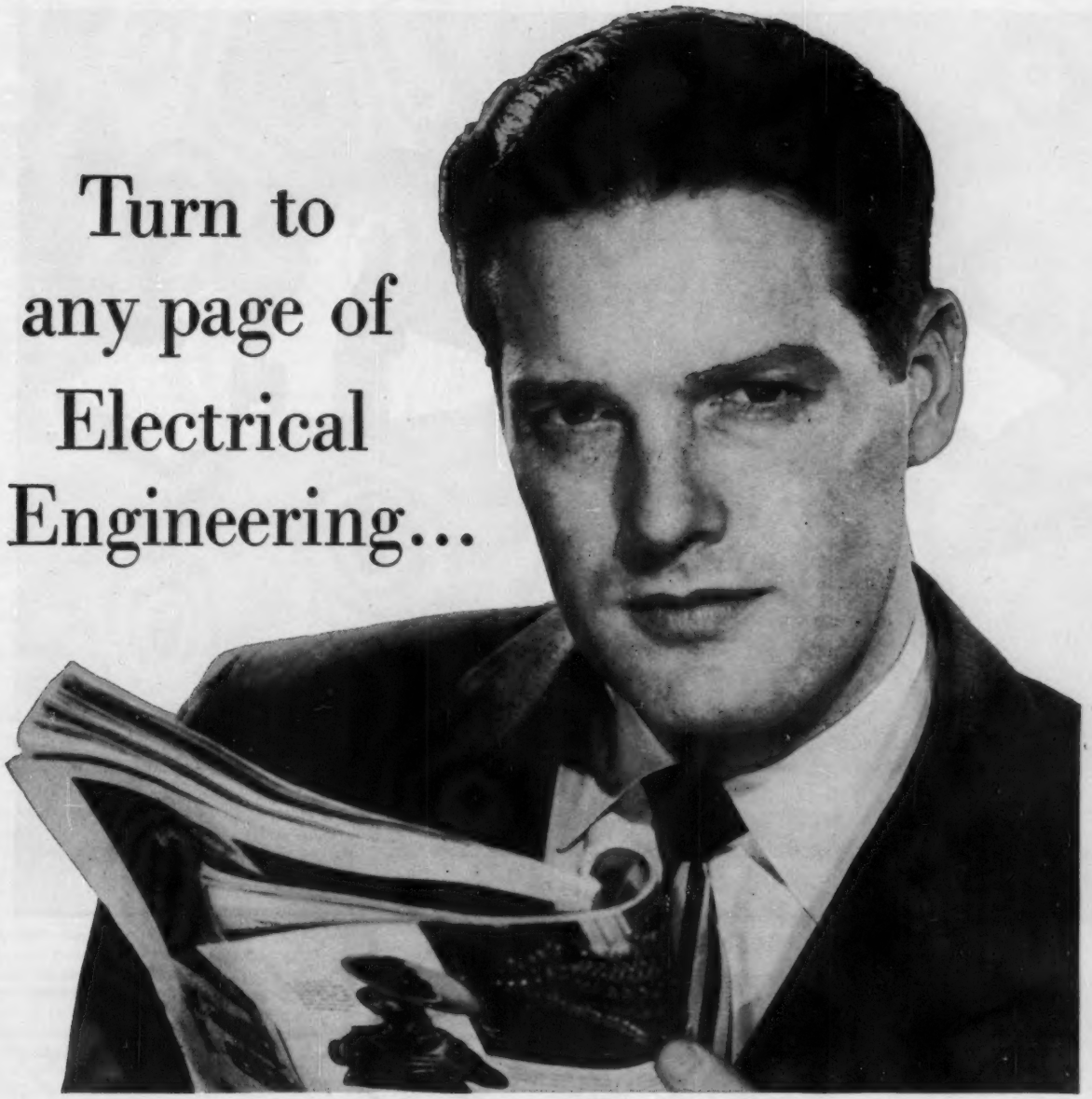

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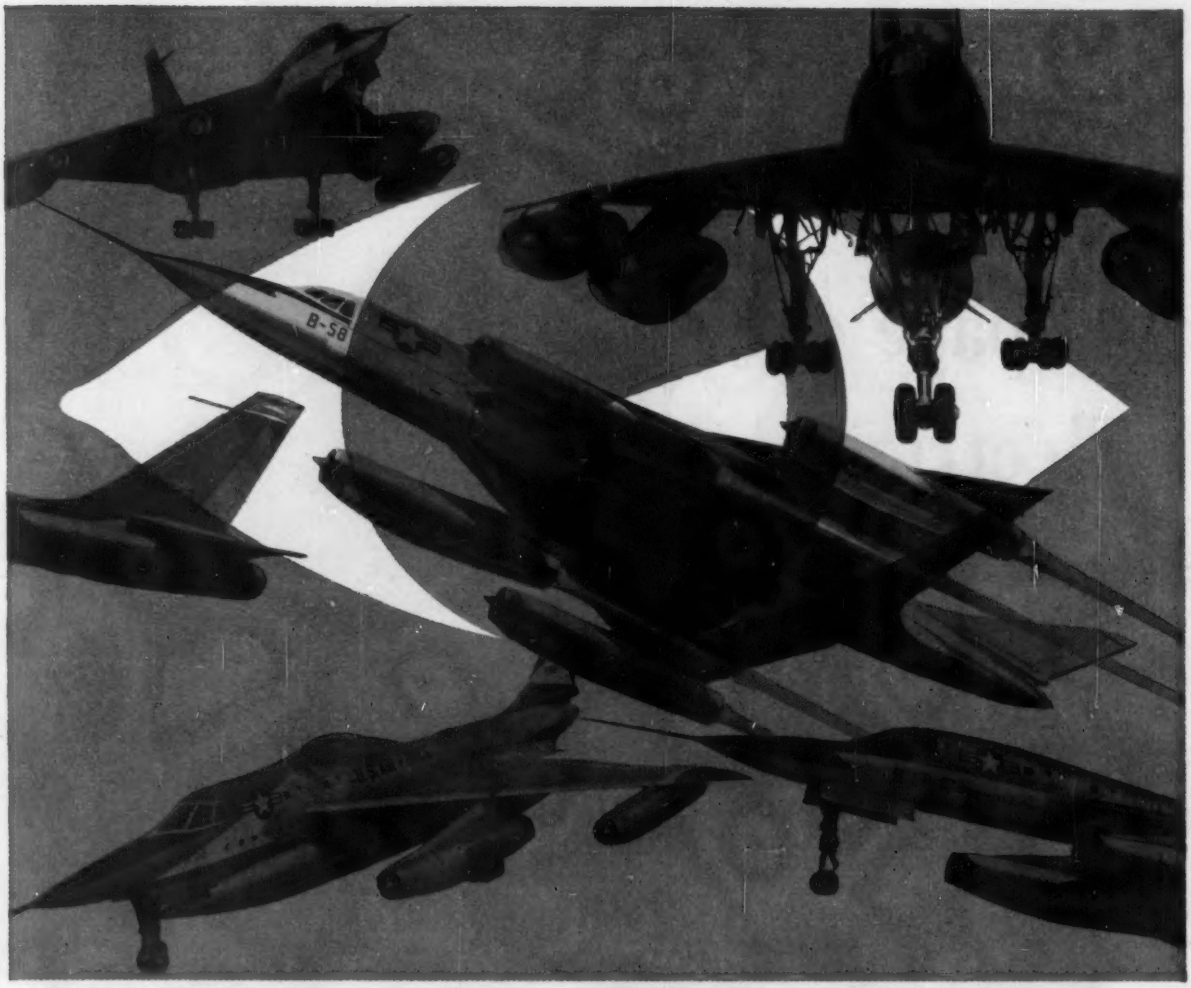

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Trade Literature

(Continued from page 64A)

Drafting Room Short Cuts in Booklet. A booklet outlining ways in which Kodagraph reproduction materials can provide short cuts and savings in reproduction departments, drafting rooms, and in the field, has been published by Eastman Kodak Company. Entitled "Short Cuts and Savings with Kodagraph Reproduction Materials," the 12-page booklet diagrams applications for the materials: to protect original drawings, simplify print distribution, restore old and worn drawings, reproduce blueprints and direct-process prints, speed revision of drawings, permit combining of standard designs, and save drafting time with photodrawings. The booklet is available without charge from Graphic Reproduction Division, Eastman Kodak Company, Rochester, N.Y.

Stampings Folder. A 4-page, informational folder has been produced by The Staver Company which details the services of the company in the fabrication and production of stampings from rare and specialized metals and includes a handy quick reference chart covering the properties and typical uses for 20 different types of rare or special metals. Copies are available on request. Write to The Staver Company, 45-51 N. Saxon Ave., Bay Shore, N. Y.

Lubricant Chart. Bulletin *116* contains a valuable chart for machine shop personnel showing where and how Molykote lubricants should be applied. The chart indicates the equipment on which the lubricant promises to excel, the method of applying the lubricant, and the benefits which can be expected. Copies are available from The Alpha-Molykote Corporation, 65 Harvard Ave., Stamford, Conn.

Receiver Recorder and Controller. The 16-page Product Specification *E12-5* contains details of newly developed plug-in components for the Bailey recorder. Twelve types of receivers, controllers, retransmitters, and direct measuring devices from which the recorder may be custom-built are described. Also illustrated is the sealed, automatic, 1-year inking system and many exclusive features. Available on request from Bailey Meter Company, 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Polyester Tape. A 4-page brochure, intended to aid designers in selecting polyester tapes, lists physical and electrical properties of Scotch brand polyester tapes, as well as the military specifications met by the tapes. The booklet may be obtained by writing to Minnesota Mining and Manufacturing Co., Dept. *D8-187*, 900 Bush St., St. Paul 6, Minn.

AN Connector Chart. An easily used wall-chart for specifying AN connectors is available. This colorful 22 inch by 28 inch sheet graphically provides a simple method for selecting the proper AN connector for an application. For your copy, contact The Deutsch Company, 7000 Avalon Blvd., Los Angeles 3, Calif.

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ASSOCIATE PROFESSOR for Electrical Engineering Department. Ph.D. degree preferred. Opening in electronics. Salary commensurate with experience and education. Position available September 1958. Write Head, Electrical Engineering Department, South Dakota School of Mines and Technology, Rapid City, South Dakota.

ELECTRICAL ENGINEER, physicist, chemist for fundamental project on effects of radiation on dielectrics. Capacitor experience desirable. Send resume to: Radiation Research Corporation, 1114 First Avenue, New York, New York.

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(June 1954)

At the 1954 Winter General Meeting the Subcommittee on Dielectrics and its Working Group sponsored three sessions of papers covering various phases of the problem of evaluating insulating materials. Since these papers review much of the recently developed information on this subject, it was decided to reprint them in this form. As test methods on the thermal evaluation of insulating materials become available, more and more data on thermal stability of both the newer and the older materials should develop, and eventually make possible the rational revision of AIEE Standard Number 1 on a sound basis.

The 72-page printed publication contains 16 papers and discussions, presented at the 1954 AIEE Winter General Meeting.

Publication S-61 is available at the price of $1.50 to members and nonmembers. Send orders to:

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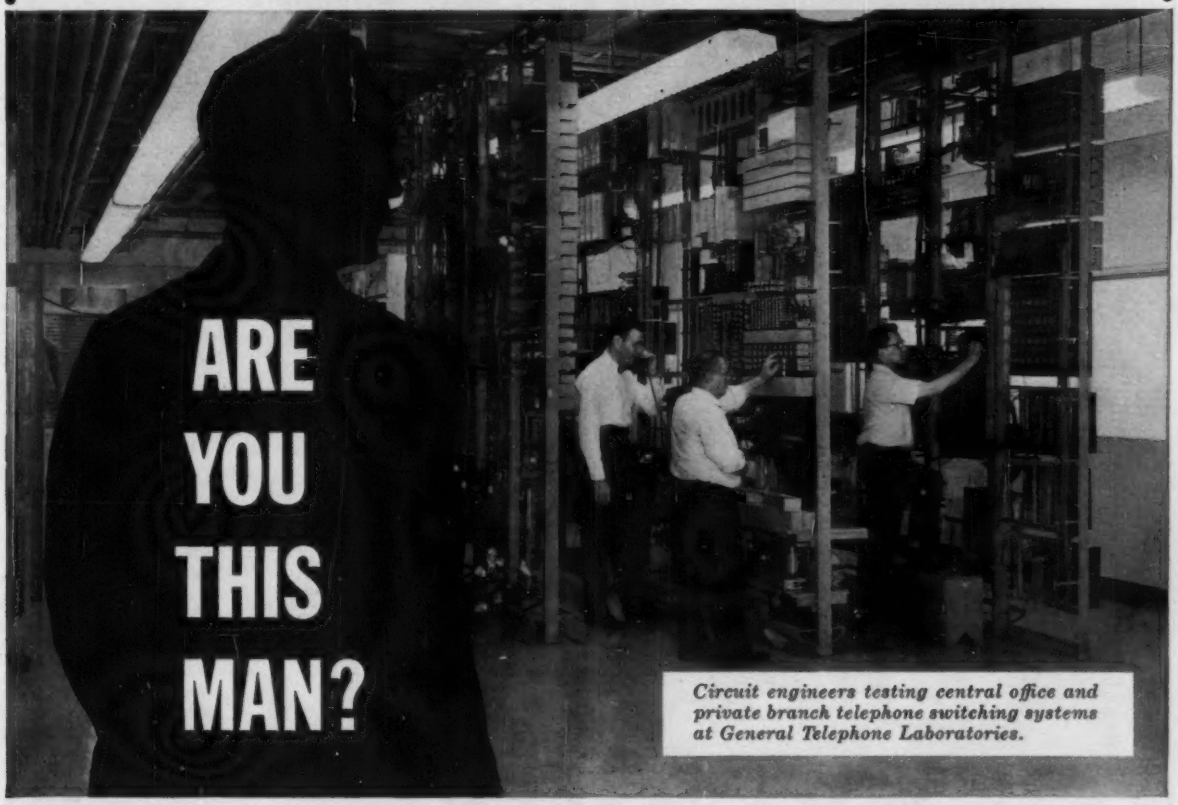

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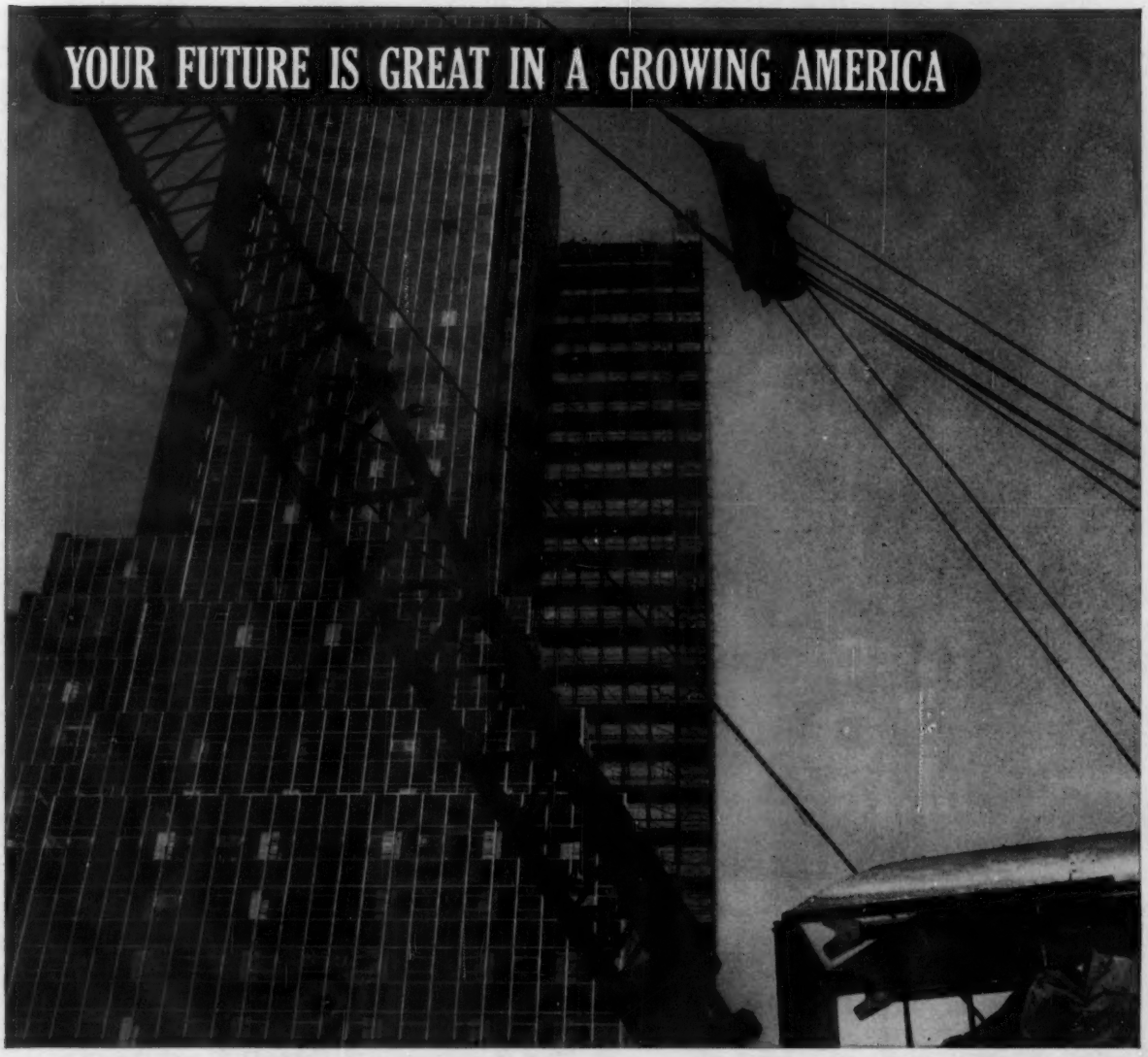

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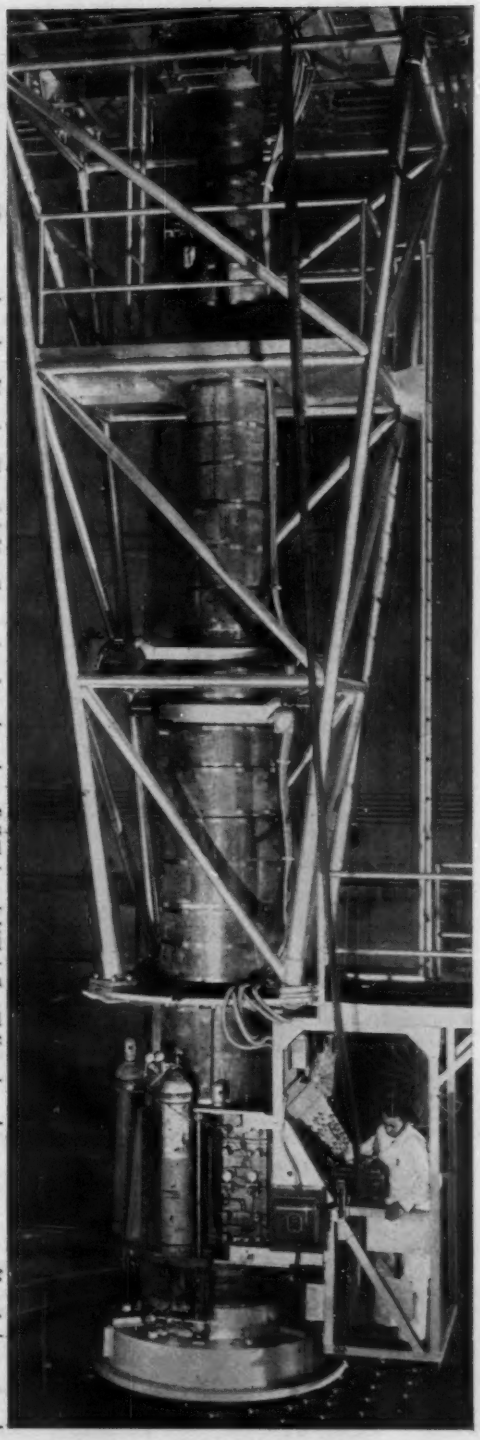

SRE Fuel Handling Cask. The Sodium Reactor Experiment and the Organic Moderated Reactor Experiment are both in successful operation. Plans for several central station plants based on these experimental power reactors are underway. AI is also conducting an advanced power reactor study for Southwest Atomic Energy Associates. Overseas, AI has already sold 5 reactors, and is affiliated with ASEA of Sweden and the new company INTERATOM (with DEMAG, West Germany).

Completely Revised, October 1956 Issue

Electric Power Distribution for Industrial Plants

(RED BOOK)

No. 952

The purpose of this publication is to bring to the attention of engineers, owners, and plant management the important features of well-designed electric distribution systems that result in satisfactory performance of utilization equipment and efficient operation of the plant; it covers the features of the electric distribution systems which are applicable to most types and sizes of industrial plants. It sets forth the elements of the distribution system both as to what to do to accomplish desired results and the reasons for them. It does not explain in detail how to accomplish the final results.

Basic information is included to determine the approximate load requirements of industrial plants, the type of distribution system, the distribution voltages, and voltage regulation, as well as information to assist the engineer in the selection of transformers, circuit breakers, relays, meters, fuses, cables, bus, and miscellaneous equipment needed in the design of an adequate electric distribution system for present and future load conditions. Operating and maintenance problems are dealt with only in so far as they affect system and equipment selection. Basic information is included to determine load requirements, type of system, and voltages. Data are included to assist selecting transformers, circuit breakers, relays, meters, fuses, conductor, and miscellaneous equipment for present and future loads.

$3.50 per copy (50 per cent discount to AIEE members); 172 pages

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Companion Publication (Also October 1956)

Grounding of Industrial Power Systems

No. 953

This publication covers the problems of system grounding, connecting the frames and enclosures of electric apparatus to a ground system, the problems of static, the methods of protecting structures against the effects of lightning, and the problems of obtaining a low resistance connection to the earth.

The popular name "Green Book" now applies to this new publication rather than to Interior Wiring Design for Commercial Buildings as before. The latter publication is out of print pending revision and when the new edition is available it will be known as the "Gray Book."

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Power Supply for Resistance Welding Machines
(April 1952)

AIEE Special Publication S-45 is a report of the AIEE Subcommittee on Power Supply for Resistance Welding Machines. Recognizing that the installation and use of any resistance welding process vitally concerns not only the industrialist requiring the process but also the welding machine manufacturer and the utility supplying the electric power as well, the committee has in this report brought together much pertinent data from the knowledge, literature, and experience in all these fields.

This publication supersedes the AIEE reports of the same title presented in 1940-1. The new work is required by developments in welding machines, new processes, better analysis of certain phenomena (such as measurement of instantaneous loads, and interference between welders), and a clearer understanding of the whole problem of power supply for resistance welders.

This report is not intended to be a complete solution of all welding problems, but should direct attention to the special electrical features involved so that a full analysis developed for a welding project can be readily understood and utilized by manager, master mechanic, and electrical engineer.

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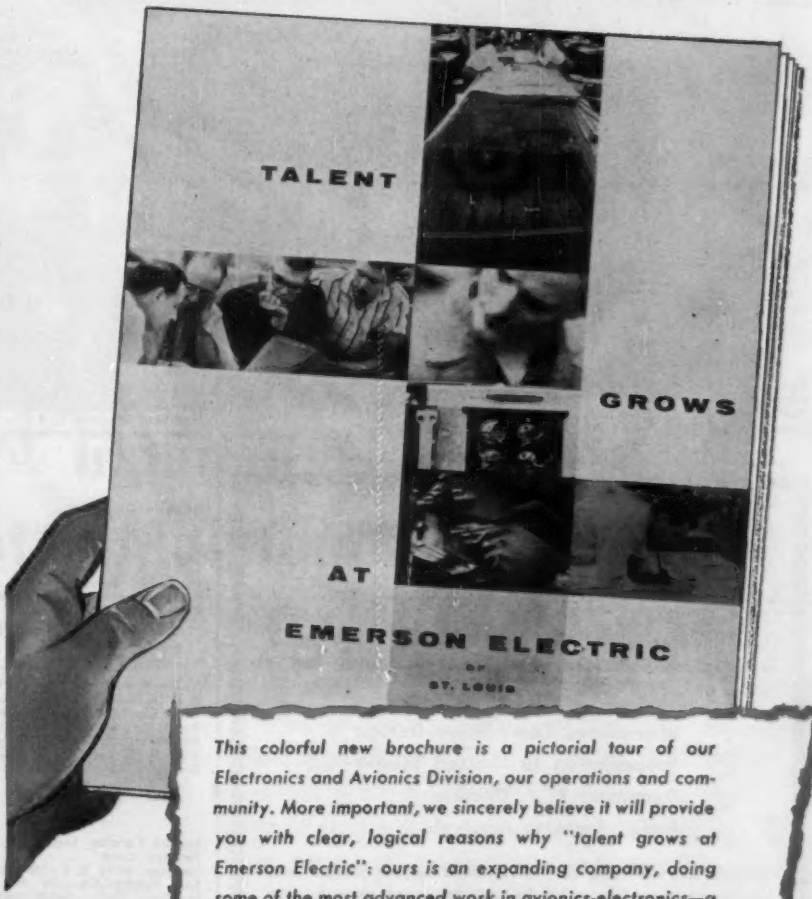

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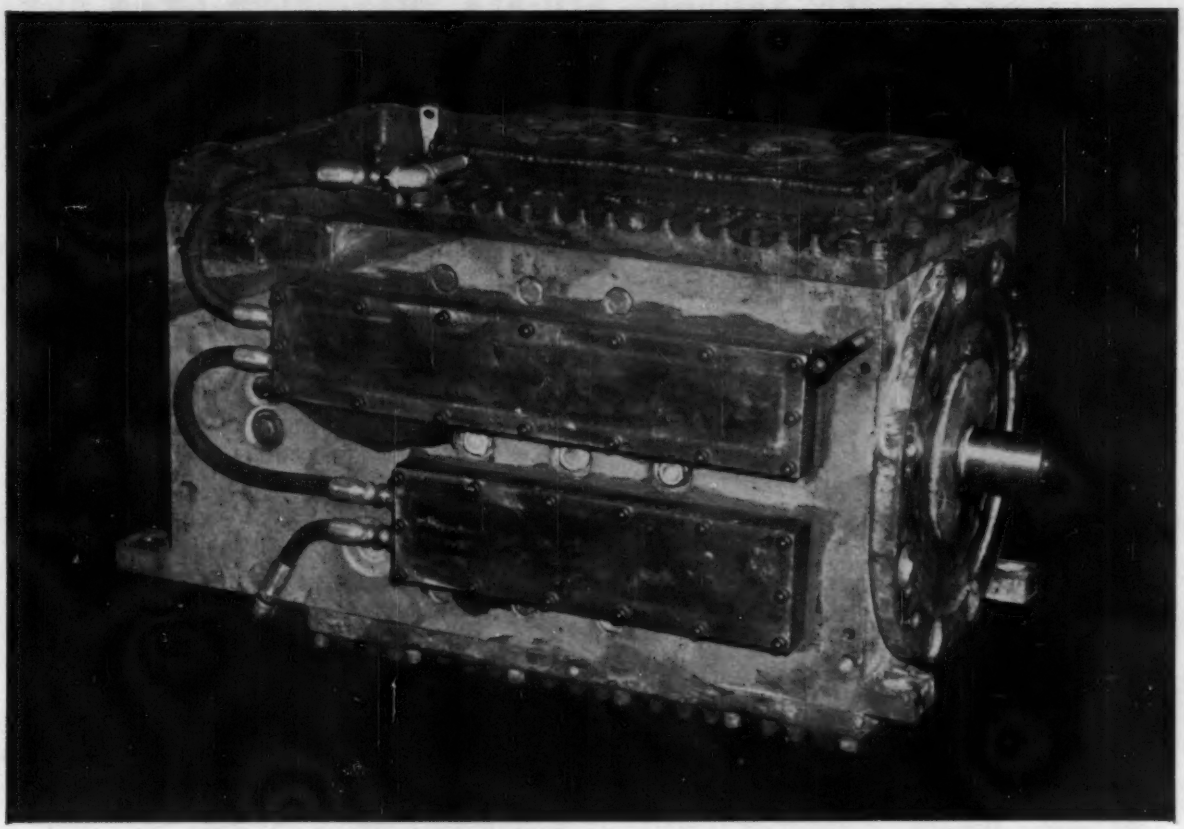

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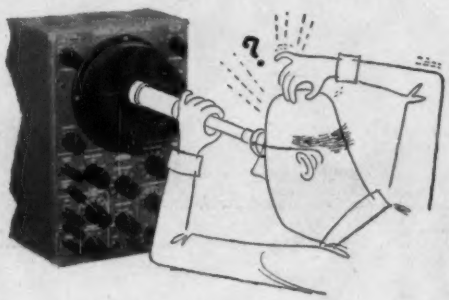

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RANGES:
0.5 to 2,000,000 megohms at 500 volts and to 200,000 megohms at 50 volts. Meter multiplier has six decade steps.

TWO TEST VOLTAGES provided internally: 50v or 500v.

ACCURACY:

Test Voltage	Accuracy as Percent of Meter Indication		
	Low End	Mid Scale	High End
50 v*	±5%	±10%	±14%
500 v**	±3%	±8%	±12%

*Additional ±5% error on lowest multiplier setting
**Additional ±2% error on highest multiplier setting

SWITCH POSITION for standardizing calibration at 500 volts.

GUARD AND GROUND terminals permit measurements on either 2- or 3-terminal networks.

HIGHLY-STABILIZED power supply permits capacitor leakage measurements without annoying meter fluctuations caused by line-voltage variations.

LIGHT ON PANEL warns when 500v is in use.

PANEL SWITCH permits convenient shunting of UNKNOWN terminals to discharge capacitive component of unknown.

ALL OUTSIDE SURFACES of "hot" binding posts are coated with insulating polystyrene to prevent accidental shock.

PRICE: $255

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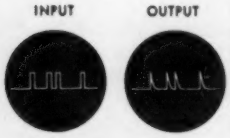
RCA-6499 RADECHON: Charge Storage Tube; Single-Beam, Barrier-Grid Type; Non-Equilibrium Writing and Capacitance-Discharge Reading. One of a line of RCA Radechons.

5 ways RCA RADECHONS handle electronic data... effectively

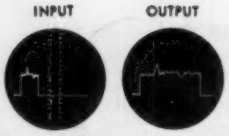
Can you name more?

Designed to "take in" electronic data—store it from microseconds to minutes—*then release the information at the same rate or at different rates,* RCA Radechons can play a key role in electronic data-processing systems for industry and the military.

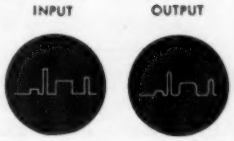
Read what these remarkable RCA Radechons can do for you—and how they do it:



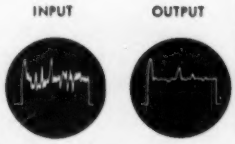
IN DIGITAL DATA STORAGE SYSTEMS, the Radechon acts as a high-speed, random-access, high-capacity memory element.



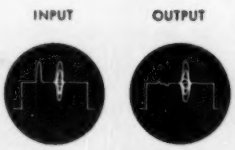
IN TIME-BASE CONVERSION APPLICATIONS, the Radechon releases a stored signal at a rate different from the input rate—as may be required in systems for the transmission of video signals over telephone lines, or in certain systems involving audio-signal multiplexing.



IN SIGNAL DELAY APPLICATIONS, the Radechon stores a signal burst—then releases it after delay periods from microseconds to minutes.



IN RADAR SYSTEMS, the Radechon offers better radar signal "detectability"—through charge integration in the storage element.



IN FIXED-SIGNAL CANCELLATION APPLICATIONS, the Radechon compares successive signals. Originally designed for "line-by-line" Moving Target Indicators, the Radechon also can be used in "area" MTI systems.

If you are working with these or other Radechon applications, get in touch with the RCA Field Representative at our office nearest you. Remember, RCA is the world leader in Radechon engineering, development, and manufacturing—and welcomes inquiries for Radechon designs to meet specific needs.

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